memorandum

DATE: July 18, 2001
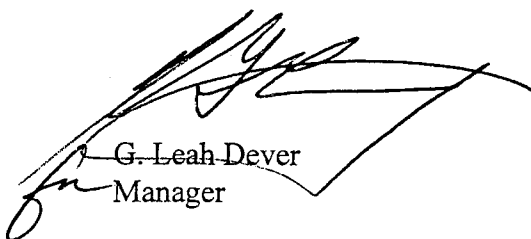
REPLY TO
ATTN OF: EM-921:McMillan

SUBJECT: ENVIRONMENTAL ASSESSMENT FOR TRANSPORTATION OF LOW-LEVEL RADIOACTIVE WASTE FROM THE OAK RIDGE RESERVATION TO OFF-SITE TREATMENT OR DISPOSAL FACILITIES

TO: Rodney R. Nelson, Assistant Manager for Environmental Management, EM-90

The subject Environmental Assessment (EA) dated March 2001 has been reviewed in accordance with our responsibilities under Department of Energy (DOE) Order 451.1A, paragraph 5a(9). Based upon this review, recommendations made by your staff, and after consultation with the Office of Chief Counsel and the National Environmental Policy Act (NEPA) Compliance Officer, I have determined that within the meaning of NEPA, the proposed action is not a major Federal action significantly affecting the quality of the human environment. Therefore, the preparation of an Environmental Impact Statement is not required. The basis for this determination is explained in the attached Finding of No Significant Impact (FONSI) and the supporting final EA.

Please note that your office is responsible for providing public notice of the availability of the EA and FONSI in accordance with 40 CFR 1506.6(b), 10 CFR 1021.322, and DOE Order 451.1B, paragraph 5e(5).

If you need further assistance or have any questions or comments, please contact David R. Allen, Oak Ridge Operations NEPA Compliance Officer at (865) 576-0411.

G. Leah Dever
Manager

Attachments

(Cc's on page 2)

ENVIRONMENTAL MANAGEMENT
DIVISION. FILE CODE NUMBER
6507.10

DOE ENVIRONMENTAL MANAGEMENT
DIVISION COR   NG
23775

cc w/attachment:
C. Borgstrom, EH-42, FORS (3 copies with 1 CD-ROM)
J. Désai, EM-32, CLVRLF
D. Allen, SE-32, ORO (2 copies)
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J. Owsley, TDEC, Oak Ridge
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E. Smith, City of Oak Ridge EQAB
S. Black, Administrator, ORR SSAB

FINDING OF NO SIGNIFICANT IMPACT

ENVIRONMENTAL ASSESSMENT FOR TRANSPORTATION OF LOW-LEVEL RADIOACTIVE WASTE FROM THE OAK RIDGE RESERVATION TO OFF-SITE TREATMENT AND DISPOSAL FACILITIES

AGENCY: U.S. DEPARTMENT OF ENERGY

ACTION: FINDING OF NO SIGNIFICANT IMPACT

SUMMARY: The U.S. Department of Energy (DOE) has completed an environmental assessment (DOE/EA-1315) for the proposed transportation of legacy and operational low-level (radioactive) waste (LLW) from the Oak Ridge Reservation (ORR) in Tennessee for treatment or disposal at various locations in the United States. Based on the results of the impact analysis reported in the EA, DOE has determined that the proposed action is not a major Federal action that would significantly affect the quality of the human environment within the context of the National Environmental Policy Act of 1969 (NEPA). Therefore, preparation of an environmental impact statement is not necessary, and DOE is issuing this Finding of No Significant Impact (FONSI).

PUBLIC AVAILABILITY OF EA AND FONSI: The EA and FONSI may be reviewed at and copies of the document obtained from:

> U.S. Department of Energy
> Public Reading Room
> 230 Warehouse Road
> Oak Ridge, Tennessee 37830
> Phone: (865) 241-4780.

Copies may also be obtained by written request from:

> U.S. Department of Energy
> Bill McMillan, NEPA Document Manager
> P.O. Box 2001
> Oak Ridge, Tennessee 37830
> Phone: (865) 241-6426.

FURTHER INFORMATION ON THE NEPA PROCESS: For further information on the NEPA process, contact:

> David R. Allen
> NEPA Compliance Officer
> U.S. Department of Energy
> P.O. Box 2001
> Oak Ridge, Tennessee 37831
> Phone: (865) 576-0411.

BACKGROUND: The DOE-Oak Ridge Operations (ORO) Office has LLW that must be transported from Oak Ridge to treatment and disposal facilities because on-site disposal is not available for the expected large life-cycle volumes, nor for the technical constituents, of many ORR LLW streams. The reservation encompasses three major DOE facilities: Oak Ridge National Laboratory (ORNL), Oak Ridge Y-12 Plant, and East Tennessee Technology Park (ETTP). Large quantities of LLW have been generated as a result of normal operations associated with research or manufacturing conducted at these facilities. DOE legacy and operational LLW on ORR (approximately 40,000 m³) is managed in compliant storage. It is estimated that 7700 m³ of waste could be generated annually from operations over the next 20 years. While a large portion of ORR LLW will eventually be shipped to other federally owned, DOE-operated disposal facilities, DOE also intends to use commercial disposal facilities when cost-effective, compliant, and in the best interest of the government.

The proposed action is to package as needed, load, and ship existing and forecasted ORR LLW to existing or future facilities at other DOE sites such as the Nevada Test Site (NTS), the Hanford Reservation, the Savannah River Site, and licensed commercial nuclear waste treatment or disposal facilities. These include Envirocare of Utah Inc. (Envirocare), Clive, Utah; Waste Control Specialists (WCS), Andrews, Texas; commercial facilities near the Savannah River Site (SRS), Aiken, South Carolina; commercial facilities near ORR; and commercial facilities near the Hanford Site, Richland, Washington. LLW will either be shipped directly from ORR to a DOE or licensed commercial disposal facility or to a DOE or licensed commercial treatment facility and then to a DOE or licensed commercial disposal facility. ORR LLW will generally be transported by truck but may also be transported by rail or intermodal carrier (i.e., truck and rail combination) when advantageous.

The impact analysis in the EA addressed the potential effects of loading and transporting accumulated legacy and ongoing operations LLW from Oak Ridge, Tennessee to destinations representative of other DOE sites and licensed commercial nuclear waste treatment or disposal facilities. The potential effects of transport over both highway and rail routes were evaluated. Evaluation of LLW being generated by ongoing operations at the ORR was based on volumes anticipated over a 20-year life cycle. The potential effects were evaluated on per shipment, annual, and 20-year bases. The EA did not address waste for which treatment and disposal are addressed pursuant to the Comprehensive Environmental Restoration, Compensation, and Liability Act of 1980 (CERCLA), on-site activities that are already being conducted as a part of routine waste management at the ORR, or activities conducted prior to loading or at the destination facilities.

ALTERNATIVES: In addition to the proposed action, impacts were also evaluated for the no action alternative. In the no action alternative, DOE would not ship and dispose of the existing and projected large quantities of ORR LLW at off-site radioactive waste disposal facilities. Relatively small volumes of ORR LLW would continue to be shipped to DOE or commercial disposal facilities under existing and previously approved categorical exclusions. Because no disposal facility for operational and legacy LLW is available on site, the existing and projected quantities of ORR LLW would continue to be stored on site, eventually requiring additional LLW storage facilities.

ENVIRONMENTAL IMPACTS:

NO ACTION

Radiological Risks from the No Action Alternative. Workers are exposed to radiological emissions in the course of conducting waste management activities at the ORR. Exposures to radiation contribute incrementally to cancer risks for workers; these risks are reported annually for the ORR as a whole

in the Annual Site Environmental Report (ASER). According to the annual report, historical risks are well below negligible levels; thus, the same can be inferred about risks from LLW on an annual basis. Storage of the same waste inventories over time would result in an increase in handling of the waste for repackaging, etc. While risks on an individual basis would not necessarily increase, the number of workers managing the waste would. As the volume of stored waste increases over time, the associated risks of managing the waste would also increase on a cumulative population basis.

Opportunities for public exposure to radiological emissions resulting from storage of LLW at the ORR are limited during routine waste management activities. Since radiological emissions have a rapid "drop off" rate over both time and distance, airborne emissions from LLW would not routinely reach ORR boundaries. Environmental media, such as soil and water, have the potential to become contaminated and subsequently migrate off site during storm events. Radiological emissions that could affect the public have historically been negligible, according to the ASER.

Members of the public and workers could potentially be exposed to radiological emissions from LLW during waste management activities in the event of a spill, accident, or lapse in adherence to safety protocols. For example, if rainwater infiltrated a container of waste and it subsequently leaked while being moved from one storage location to another, radiological releases could occur. Such releases could accumulate in the surrounding environment and be a source of both direct and indirect exposures. While risks from current inventories of LLW are quite low, increases in inventory volume would contribute incrementally to the risk of an accidental release.

Nonradiological Risks from Accidents. There are risks from accidents during routine waste management activities, just as there are for any type of physical activity. Slips, trips, and falls may occur. Workers can be injured by improper lifting or accidents with equipment. These risks generally increase with increases in the number of workers, as would be the case with the no action alternative. These risks are minimized through safety standards and worker training on the ORR as at other industrial facilities. Continued storage of LLW under the no action alternative would increase these safety risks by requiring additional handling of the same waste as repackaging and facility maintenance is required.

As waste inventories increase over time, storage facilities would need to be expanded, and new facilities would have to be constructed. This would require the use of heavy equipment and introduce accident risks during facility construction.

Air Quality Impacts. Waste management activities result in emissions from motor vehicles and building utilities. The ORR is currently in an attainment region, and emissions from LLW management activities would be below threshold levels and therefore de minimus. However, the greater Oak Ridge/Knoxville area as well as the Great Smoky Mountains National Park have had some days when ozone levels exceeded thresholds. The emissions from Oak Ridge contribute incrementally to ozone levels on a regional basis. The no action alternative would not alter air quality on the ORR or the surrounding region since the activities that would be conducted under this alternative are already being conducted.

Noise Impacts. The no action alternative would not alter noise levels on the ORR since the activities that would be conducted under this alternative are already being conducted. If construction of new storage facilities were required, noise levels in the vicinity of the construction would increase during the construction period.

Ecological Impacts. Potential radiological impacts resulting from the no action alternative on local ecological systems would be continued exposures of biota on the ORR to some radioactivity. Storage of LLW would be a relatively small portion of the total exposure ORR biota receive because the majority of the waste is containerized and stored in buildings or storage yards that provide little habitat for plants and

animals. Biota inhabiting or visiting the ORR may be exposed to both radioactivity and hazardous substances (e.g., leachate from uncontainerized scrap metal). A biological monitoring and abatement program issues reports on contaminant levels and their effects on local biota. The majority of these effects are caused by contamination originating from past activities and operations on the ORR, but LLW stored on the ORR also contributes to these effects. Exposure of biota to hazardous substances and radioactivity would be unlikely, but could occur in the event of an accidental release during routine management activities associated with the waste. Most of the waste is not very dispersible, and spill response actions would ensure that the waste were quickly recovered, thus limiting any exposure.

Construction of new storage facilities for LLW would increase noise and dust levels during construction. This could affect local animal populations, particularly during breeding seasons. Mitigation would be required to minimize erosion and sedimentation of surface water during construction as well. Overall, these effects would likely be temporary and localized.

Environmental Justice Impacts. Risks to the public as a result of the no action alternative would be similar in nature and location to current risks from LLW which are at negligible levels and spread throughout the ORR. It is unlikely that minority or low-income populations would be disproportionately affected by the risks from the no action alternative. Most risks associated with the no action alternative are risks to workers from exposure to radiological emissions and accidents. The ORR work force is not composed of a disproportionate percentage of minorities or low-income populations.

Irreversible and Irretrievable Commitment of Resources. The no action alternative would result in the irreversible and irretrievable use of necessary fuel, power, and materials for maintaining the packaging integrity of the waste and the buildings and areas used for storing the waste as well as for meeting reporting and monitoring requirements. If new storage facilities were constructed, additional building materials and energy would be used. Additional funding would be required for managing increasing volumes of LLW and for construction of new facilities.

Cumulative Effects. Implementation of the no action alternative would add incrementally to current risks for exposure of workers, the public and local biota to radiological emissions because it would increase the amount of LLW present on the ORR. It would also add to funding requirements for managing on-site waste.

PROPOSED ACTION

Radiological Risks from the Proposed Action. The potential radiological risks of shipping heterogenous LLW and scrap metal LLW by truck or rail were estimated using the following assumptions for packaging: 1) heterogenous waste would be shipped in 55-gal drums, unless it were Type B LLW under DOT regulations; 2) Type B[1] waste (less than 1 percent of the total volume) would be shipped in Type B casks; and 3) scrap metal LLW would be shipped in 8-ft x 8-ft x 20-ft long containers (intermodal type containers). The total number of anticipated shipments were estimated on annual and life cycle basis assuming that 80 drums or one container would be shipped per truck, 300 drums or one container would be shipped per railcar, and one Type B cask would be shipped per truck (per DOT regulations Type B LLW may not be shipped by rail).

The RADTRAN 4 computer code was used to estimate risks to a cumulative population, the transportation crew members, and a hypothetical maximally exposed individual (MEI) for each destination on a per shipment, an annual, and a 20-yr life-cycle basis for incident-free and accident scenarios. Risks were

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[1]Type B low-level radioactive waste refers to LLW that has characteristics triggering specific DOT regulatory requirements for packaging and shipping of radioactive materials (49 CFR 173).

estimated using a conservative assumption that all shipments of each LLW subgroup would go to each destination over the life cycle.

Impacts from Highway Operations. The greatest estimated risks for transport by truck were for the 20-yr life cycle and the most serious estimated consequence was for latent cancer fatality. These estimates using the incident-free scenario for all LLW, including Type B LLW, were:

- Total risks to the population[2] from shipment of LLW over the 20-yr life cycle ranged from 6.13×10^{-04} to 1.13×10^{-01} latent cancer fatalities, depending upon the route.
- Total risks to the MEI[3] from shipment of LLW over the 20-yr life cycle were 4.37×10^{-07} latent cancer fatalities.
- Total risks to the crew[4] from shipment of LLW over the 20-yr life cycle ranged from 2.01×10^{-02} to 8.00×10^{-02} latent cancer fatalities, depending upon the route.

It should be noted that risks to the crew and to the population were derived from an estimated collective dose of radiation and do not represent risk to an individual. The estimated risks using the accident scenario ranged from 3.18×10^{-07} to 1.08×10^{-04} for the potentially exposed population. These risk estimates represent the upper bound of anticipated risks from radiological exposure using truck transport for the proposed action.

Impacts from Using Rail Operations. The greatest estimated risks for transport by rail were for the 20-yr life cycle and the most serious estimated consequence was for latent cancer fatality. These estimates using the incident-free scenario for all LLW, except Type B LLW, were:

- Total risks to the population[2] from shipment of LLW over the 20-yr life cycle ranged from 3.38×10^{-03} to 4.81×10^{-03} latent cancer fatalities.
- Total risks to the MEI[3] from shipment of LLW over the 20-yr life cycle were 1.58×10^{-07} latent cancer fatalities.
- Total risks to the crew[4] from shipment of LLW over the 20-yr life cycle ranged from 4.77×10^{-03} to 8.00×10^{-03} latent cancer fatalities.

It should be noted that risks to the crew and to the population were derived from an estimated collective dose of radiation and do not represent risk to an individual. The estimated risks using the accident scenario ranged from 9.09×10^{-05} to 1.13×10^{-04} for the potentially exposed population. These risk estimates represent the upper bound of anticipated risks from radiological exposure using rail transport for the proposed action.

Nonradiological Risks from Emissions and Accidents as a Result of the Proposed Action. Loading waste onto transport vehicles at the ORR would present risks of accidents. These risks would be similar to, and not exceed, the risks already presented by ongoing operations. The risks of injury or fatality from highway accidents are directly proportional to the total distance traveled in a year so risks are greatest for the years with the most shipments as well as for destinations farthest from Oak Ridge. They were estimated using standard DOT accident rates for truck and railway transportation. For example, the highest fatality risk is 8.49×10^{-1} (about 8 out of 10 or an 80 percent chance of a single fatality over 1.75 million miles of travel) for shipping to Mercury, Nevada in any one year between 2001 and 2005. Thus the risk of a fatality on a per shipment basis would be only 1.02×10^{-3} (about 1 in 1000 or a tenth of a percent chance of a fatality over 2095 miles of travel). It should be noted that these risks of a potential accident are estimated using default rates for all types of truck shipments and are not a prediction that a fatality

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[2] Risks to the population refers to the average risk to an individual times the number of people potentially exposed.

[3] Risks to the maximally exposed individual (MEO) is a hypothetical member of the public living by the highway or railroad and who is exposed to every shipment at a distance of 98 ft.

[4] Risks to the crew refers to the summed risk for exposure of two individuals (workers) over the total distance of all shipments combined.

would occur during shipment of LLW. These estimated risks from an accident would be shared among the entire potentially exposed population; i.e., individuals in passing cars and at rest stops and the crew for the entire 835 shipments, similar to the estimated risks of exposure to radiological emissions.

While the possibility of an accident during the transport of LLW exists, it is probable that the risks may be somewhat lower than those presented here based on the relatively low historic accident rate for LLW shipments (53 in 2 million shipments between 1994 and 1998).

The rail transportation model assessed impacts of transporting ORR LLW by regularly scheduled commercial rail. As there would be no additional increase in rail traffic over the routes between Oak Ridge and the proposed disposal sites, no increase in the non-radiological health effects or accident risks that exist from regularly scheduled rail traffic would occur as a result of the proposed action.

Air Quality Impacts. The maximum number of truck shipments that will occur in any one year is 835. It is expected that shipments would be spread evenly over the year; thus the maximum in any one week would be 16, or two to three/day. A brief analysis was undertaken to determine the impact of the proposed shipments relative to the threshold emission levels in nonattainment areas described by EPA in its air conformity regulations [40 CFR 93.153(b)(1)]. The proposed routes were evaluated for maximum road miles proposed to be traveled for each criteria pollutant. Carbon monoxide, ozone, and particulate matter smaller than 10 micrometers (PM_{10}) were the criteria pollutants used.

The EPA threshold for carbon monoxide for all nonattainment and maintenance areas is 200,000 lb (100 tons)/year for any new proposed activity; for ozone (measured by its precursor NO_x for "ozone attainment areas outside an ozone transport region" such as Dallas-Ft. Worth) is 200,000 lb (100 tons)/year; for PM_{10} for all moderate nonattainment areas is 200,000 lb (100 tons)/year for any new proposed activity. For the standard commercial semitractor trailer vehicles that would be used for pulling waste shipments, the average emission for carbon monoxide was estimated as 11.03 g/mile, the NO_x emission rate as 22.91 g/mile, and the emission factor for PM_{10} as 14.87 g/mile.

Using a maximum of 835 shipments (truck round trips)/year, the estimated emission rates for carbon monoxide, ozone, and PM_{10} were all below de minimus thresholds. Therefore, air emissions within all nonattainment areas along shipment routes are well below the EPA threshold emission levels, and thus require no formal conformity analysis.

Noise Impacts. Because the dominant noise source along the route is from the passage of vehicles, the issue is whether the proposed transportation shipping campaign would significantly increase traffic flow and noise level. Even if the assumed shipment rates were increased several times above the anticipated maximum of two to three/day, no noticeable change in common highway noise along any part of the routes would be expected between ORR and NTS, Hanford, Envirocare, SRS, the surrounding ORR area, or WCS.

No increases in noise levels or frequency would be anticipated from rail transportation because regularly scheduled commercial trains would be used.

Ecological Impacts. Exposure of biota to the hazardous substances and radioactivity contained in the LLW could potentially occur if an accident that released the waste from both the transport vehicle and a container were to occur. If such an accident were to occur, emergency spill response measures would be immediately initiated. Every effort would be made to recover all of the waste and any contaminated media. Most of the waste sub-groups are solids and are not readily dispersable by wind. If biota were exposed to the LLW under these circumstances, the effects would be localized and temporary. Such effects could have adverse effects on individual organisms, but would not affect populations of organisms.

Other resources or areas that are not expected to be impacted by the proposed action include floodplains, wetlands, state or federally protected species and habitat, prime or unique farmland, wild and scenic rivers, historic or cultural resources, park lands, and other ecologically critical areas.

Environmental Justice Impacts. The dominant risk associated with incident-free transportation of LLW by highway would be the exposure of the public to radiation at rest stops followed by exposure of truck crews. Both the risks from expected exposures and from vehicle emissions that would be contributed by the LLW transportation program were low in comparison to background radiation exposure and from other emissions. The estimated risks resulting from transportation by rail were as low or lower than from highway transportation.

Individual access and use of public highways or rest stops that would be used by trucks shipping LLW is not limited or restricted to any particular population group, economically disadvantaged or advantaged. Similarly, access to and use of railways are open to the public, although safety considerations within rail yards would often limit where the general public might approach a train. Although it is expected that the percentage of the total population comprised of minority or low-income households would vary along the rail and highway routes for the proposed action, no disproportionate effects to those minority or low-income households along the routes would occur. These groups would be subject to the same negligible impacts as the general population.

Irreversible and Irretrievable Commitment of Resources. Irreversible and irretrievable commitments of resources include resource loss (such as burning of fossil fuel) and foregone resources (i.e., resources that would remain but would be inaccessible or could not be used, such as land used for building construction). Implementation of the proposed action will result in the irreversible and irretrievable use of necessary fuel, oil, and tires for transport and some transport packaging materials for the waste. The majority of waste, however, will be transported and disposed of in the packaging used for storage.
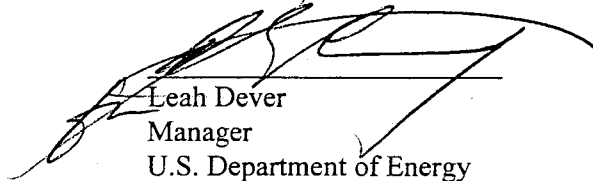
Cumulative Effects. Cumulative risks to workers from exposure to radiation are no more likely under the proposed action than risks under the no action alternative. Worker exposures will occur from stored LLW when workers monitor the waste and potentially repackage or move it for maintenance purposes. The cumulative effects for this would be bounded by regulatory ceilings just as they are for transport of the waste. The potential for risks from exposure to radiation for the public would initially be less under the no action alternative because the waste would not be moved along a public roadway. However, as volumes of stored waste increase through time, the inventory of radioactivity present at ORR would increase and the potential for an accidental release could also increase.

Cumulative effects from air emissions are a problem in modern society and are the cause of our regulatory emissions and permitting programs. Certainly, transport of the waste would cause emissions of combustion products, which add incrementally to air pollution and must be minimized as much as possible. However, beneficial effects are also considered in evaluation of cumulative effects. If the proposed action is taken, new storage areas for LLW will not be constructed on ORR, and less monitoring will be required. Emissions from motor vehicles used to travel to and around storage sites will decrease, and emissions from equipment used to construct new storage areas will not be required. These emissions would result from the no action alternative.

DETERMINATION: Based on the findings of this EA, DOE has determined that the proposed transportation of legacy and operational low-level (radioactive) waste from the Oak Ridge Reservation in Tennessee for treatment or disposal at representative DOE sites and licensed commercial facilities located in the continental United States does not constitute a major federal action that would significantly affect the quality of the human environment within the context of the National Environmental Policy Act. Therefore,

preparation of an environmental impact statement is not required.

Issued at Oak Ridge, Tennessee, this _18th_ day of _July_ 2001.

Leah Dever
Manager
U.S. Department of Energy
Oak Ridge Operations
Oak Ridge, Tennessee

DOE/EA-1315

Environmental Assessment
for Transportation
of Low-Level Radioactive Waste
from the Oak Ridge Reservation
to Off-Site Treatment or Disposal Facilities

March 2001

U.S. Department of Energy
Oak Ridge Operations
Oak Ridge, Tennessee
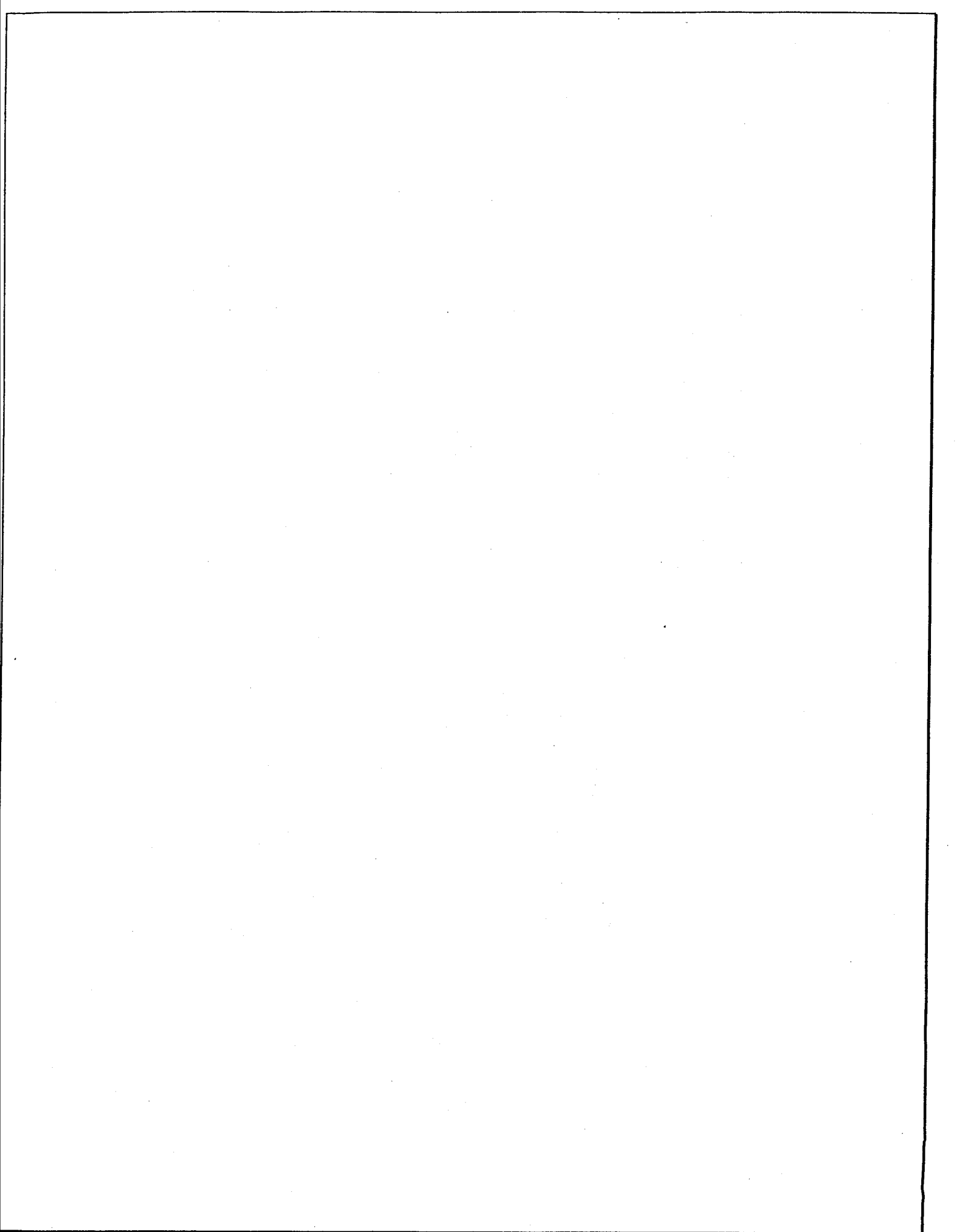
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Environmental Assessment
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March 2001

U.S. Department of Energy
Oak Ridge Operations
Oak Ridge, Tennessee

CONTENTS

FIGURES

TABLES

ACRONYMS

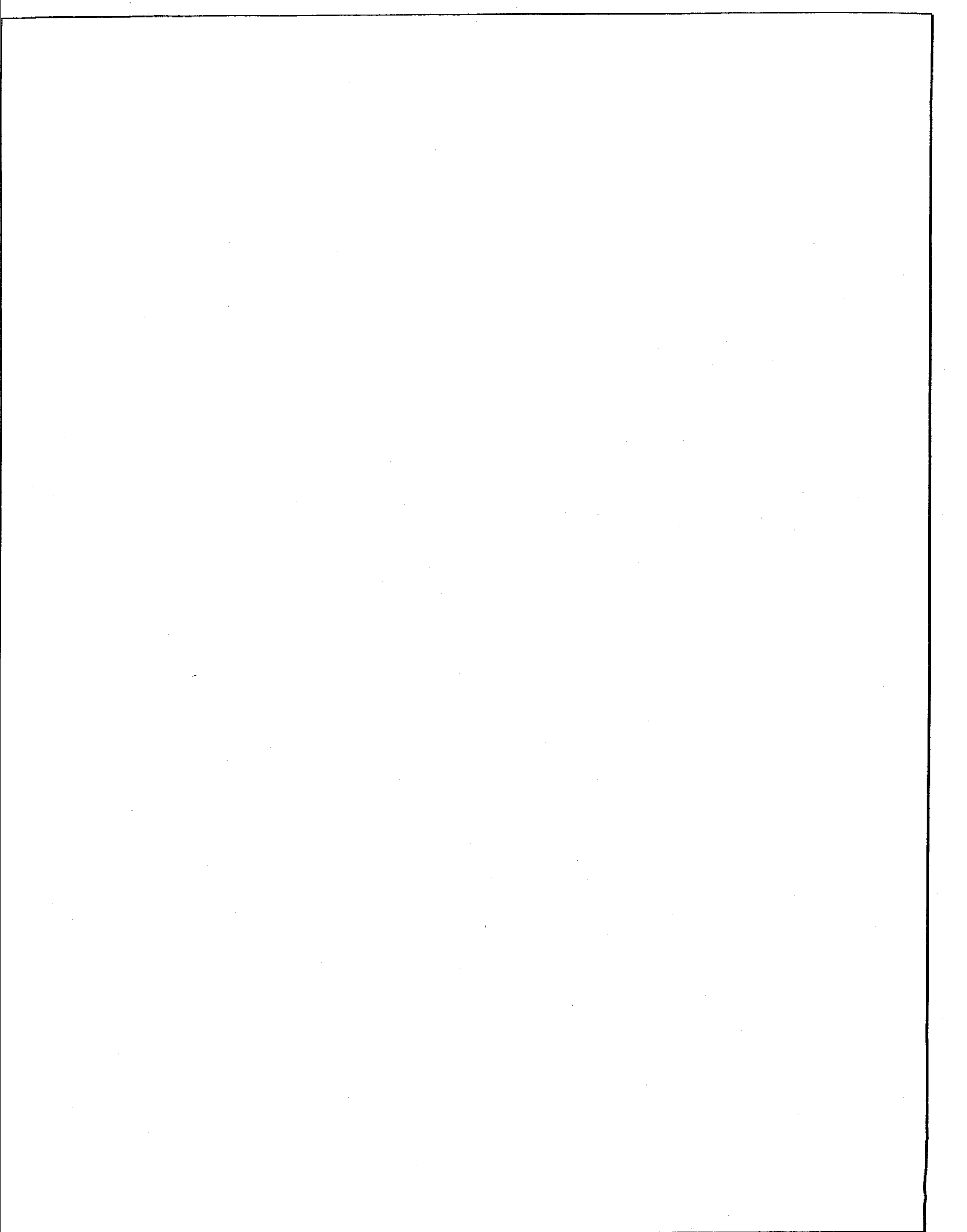|	
ASER	*Annual Site Environmental Report*
ASME	American Society of Mechanical Engineers
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EA	environmental assessment
EPA	Environmental Protection Agency
ETTP	East Tennessee Technology Park
HDDV	heavy duty diesel-powered vehicle
LCF	latent cancer fatality
LLW	low-level (radioactive) waste
MEI	maximally exposed individual
NAAQS	National Ambient Air Quality Standards
NCRP	National Council on Radiation Protection
NEPA	National Environmental Policy Act of 1969
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
ORR	Oak Ridge Reservation
SIP	state implementation plans
SRS	Savannah River Site
WAC	waste acceptance criteria
WCS	Waste Control Specialists
WM-PEIS	*Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste*
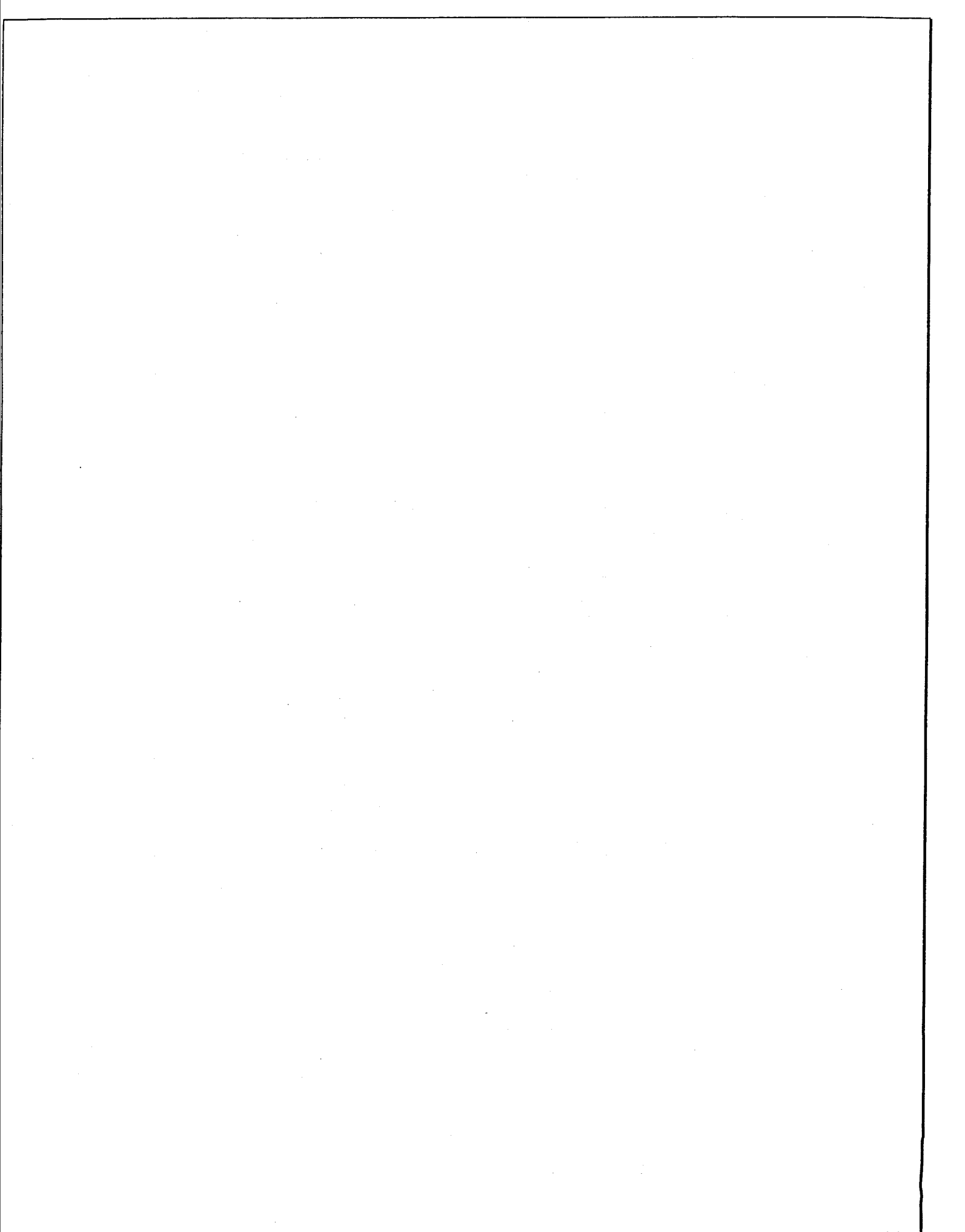
1. INTRODUCTION

The U.S. Department of Energy (DOE) proposes to transport low-level (radioactive) waste (LLW) from the Oak Ridge Reservation (ORR) in Tennessee for treatment or disposal at various locations in the United States. As a federal agency, DOE must comply with the National Environmental Policy Act of 1969 (NEPA) by considering potential environmental issues associated with its proposed action in the decision-making process. The Council of Environmental Quality (CEQ) promulgated regulations to implement NEPA [40 *Code of Federal Regulations* (CFR) 1500 et seq.] and directed federal agencies to develop their own implementing regulations for NEPA. DOE regulations (10 CFR 1021) provide additional direction for conducting NEPA reviews of proposed DOE activities. This environmental assessment (EA) for the transport of LLW has been prepared in accordance with both CEQ and DOE regulations and with DOE Orders and guidance (e.g., DOE Order 451.1A).

1.1 PURPOSE AND NEED FOR ACTION

The DOE-Oak Ridge Operations (ORO) Office has LLW that must be transported from Oak Ridge to treatment and disposal facilities. LLW is waste in which the radioactive component meets the DOE definition of LLW (DOE Order 435.1). DOE-ORO is responsible for all waste management activities on the 34,500-acre ORR. The reservation encompasses three major DOE facilities: Oak Ridge National Laboratory (ORNL), Y-12 National Security Complex, and East Tennessee Technology Park (ETTP). Large quantities of LLW have been generated as a result of normal operations associated with research or manufacturing conducted at these facilities. DOE legacy and operational LLW on ORR (approximately 40,000 m^3) is managed in compliant storage. It is estimated 7700 m^3 of waste could be generated annually from operations over the next 20 years.

Although LLW was disposed of in shallow burial grounds on the ORR from the mid-1940s until the early 1990s, on-site disposal is not available for the expected large life cycle volumes or the technical constituents of many ORR LLW streams. While a large portion of the ORR's LLW will eventually be shipped to other federally-owned, DOE-operated disposal facilities, DOE also intends to use commercial disposal facilities when cost-effective, compliant, and in the best interest of the government. DOE Headquarters (HQ) has determined that disposal at commercial facilities is appropriate in these circumstances as long as the facilities meet all regulatory and licensing requirements for acceptance of LLW including successful completion of DOE audits to determine the adequacy of the commercial facility.

1.2 SCOPE OF THIS ASSESSMENT

The scope of this assessment is limited to evaluation of the potential effects of loading and transporting accumulated legacy and ongoing operations LLW from Oak Ridge, Tennessee to destinations representative of other DOE sites and licensed commercial nuclear waste treatment or disposal facilities. The potential effects of transport over both highway and rail routes is evaluated. Evaluation of LLW being generated by ongoing operations at the ORR is based on volumes anticipated over a 20-year life cycle. The potential effects are evaluated on a per shipment, annual, and 20-year basis. The scope of this assessment does not include waste for which treatment and disposal are addressed pursuant to the Comprehensive Environmental Restoration, Compensation, and Liability Act of 1980 (CERCLA), nor does it include activities conducted before departure or at the destination facilities.

This assessment is intended to supplement and update the previous NEPA evaluation of LLW transport that was conducted as part of the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (WM-PEIS) (DOE 1997a). This assessment expands the scope of the previous analyses to include commercial facilities as potential destinations as these were not included in the WM-PEIS evaluation of transportation and expands consideration of the shipment of Type B LLW. Type B LLW is waste that has specific characteristics that trigger additional packaging and other requirements under Department of Transportation (DOT) regulations (see Glossary for more detail).

This assessment also updates the LLW volumes for Oak Ridge that were included in the WM-PEIS analyses. Current waste minimization and pollution prevention efforts on the ORR, coupled with changed mission and operational plans, have resulted in significant decreases in the anticipated volume of LLW that will be generated over the next 20 years. Shipment schedules have also been updated. While this assessment tiers to the WM-PEIS, it also references, as appropriate, other NEPA evaluations that include the impacts of transporting LLW from ORR, such as the *Final Environmental Impact Statement for the Nevada Test Site and Off-site Locations in the State of Nevada* (DOE 1996b).

This assessment does not include an evaluation of on-site activities that are already being conducted as a part of routine waste management at the ORR. Routine activities include, but are not limited to, monitoring, sampling and analyses for waste characterization, waste inspection, staging, repackaging, and on-site transport activities that are required to maintain the waste in a safe configuration during storage.

In addition to the consideration of impacts from waste management activities at DOE facilities provided by the WM-PEIS, some commercial facilities have undergone NEPA reviews as a part of their licensing requirements by the Nuclear Regulatory Commission (NRC) or NRC-authorized state agencies. This assessment does not include the potential impacts from activities conducted at destination facilities. Per DOE guidance, while analysis of impacts from a vendor's action may be within the scope of DOE's review obligation, "... the level of detail should be commensurate with the importance of the impacts or issues related to the impacts. If DOE's proposed waste load would be a small part of the facility's throughput and the facility would operate well within established standards, then the vendor's part of DOE's proposal would be low on the *sliding (sic)* scale, and a statement of this context would adequately characterize the impacts." (DOE, *"Lessons Learned"*, 1st quarter, 1996). Waste volumes anticipated over a 20-year life cycle comprise, or would comprise, less than 10 percent of the capacity of any one individual commercial facility. The commercial facilities that will be used to treat the mixed waste are required to operate within the bounds of federal and state requirements such as the NRC or Agreement State licenses, Resource Conservation and Recovery Act permits, Toxic Substances Control Act of 1976 authorizations, air and water permits, and Occupational Safety and Health Administration regulations. Based on the above evaluation, impacts from activities conducted by existing commercial facilities are not considered further in this assessment.

This assessment also does not include the transportation of CERCLA LLW within the ORR because NEPA evaluations of CERCLA actions on the ORR are conducted as part of the CERCLA process pursuant to *DOE's 1994 Secretarial Policy on NEPA*. In addition, the *Record of Decision for the Disposal of Oak Ridge Reservation Comprehensive Environmental Response, Compensation, and Liability Act of 1980 Waste* (DOE 1999a) provides for construction of a land disposal facility for CERCLA waste on the ORR. This facility will be authorized to accept only CERCLA wastes.

2. PROPOSED ACTION AND ALTERNATIVES

2.1 PROPOSED ACTION

DOE proposes to package as needed, load, and ship existing and forecasted ORR LLW to existing or future facilities at other DOE sites such as the Nevada Test Site (NTS), the Hanford Reservation, the Savannah River Site, and licensed commercial nuclear waste treatment or disposal facilities. These include Envirocare of Utah Inc. (Envirocare), Clive, Utah; Waste Control Specialists (WCS), Andrews, Texas; commercial facilities near the Savannah River Site (SRS), Aiken, South Carolina; commercial facilities near ORR; and commercial facilities near the Hanford Site, Richland, Washington. LLW would either be shipped directly from ORR to a DOE or to a licensed commercial disposal facility or DOE or licensed commercial treatment facility and then to a DOE or licensed commercial disposal facility. [GTB1]ORR LLW will generally be transported by truck but may also be transported by rail or intermodal carrier (i.e., truck and rail combination) when advantageous. In general, all of these sites will be discussed in reference to their closest city.

2.2 SOURCES OF ORR LLW

LLW from all three ORR facilities is considered under the proposed action. Each facility and its common forms of LLW are briefly described in the following sections. In addition to ongoing operations, approximately 40,000 m^3 of legacy LLW are already in storage. Table 2.1 summarizes the waste generating activities and associated LLW streams for each site. Additional information on waste types, volumes, and shipping assumptions, and a discussion of analytical methods are in Sect. 4.2.

2.2.1 East Tennessee Technology Park

ETTP was originally constructed in the 1940s as the home of the Oak Ridge Gaseous Diffusion Plant, which was part of the U.S. Army Manhattan Project. The plant's mission was production of highly enriched uranium for nuclear weapons. After military production of highly enriched uranium was concluded in 1964, the plant processed only slightly enriched uranium to be fabricated into fuel elements for commercial nuclear reactors. Other missions included development and testing of the gas centrifuge method of uranium enrichment and development of laser isotope separation. By 1985, demand for enriched uranium had declined, and the gaseous diffusion process was placed in standby mode. Enrichment operations were formally shut down in 1987.

Site	ETTP	ORNL	Y-12 Plant
Waste generating activity	Building demolition/ reuse, waste operations, and stored legacy waste	Research laboratory operations, waste operations, and stored legacy waste	Nuclear defense machining and manufacturing work, waste operations, and stored legacy waste
	Primarily a DOE Environmental Management Site	Primarily a DOE Energy Research Site	Primarily a DOE Defense Programs Site
Estimated legacy inventory of LLW	16,000 m³	6,000 m³	18,000 m³
Forecasted future annual generation rate of solid LLW	700 m³	2,500 m³	4,500 m³
	· Wastewater sludge and treatment residue · Dry active waste (paper, PPE, soft solids, etc.) · Residues from compaction and incineration · Construction debris · Soil · Radioactive scrap metal · Nonhazardous chemicals and laboratory packs · Fissile and thorium waste	· Wastewater sludge and treatment residue · Monoliths (remote handled) · Dry active waste · Soil · Radioactive scrap metal · Type B* waste · Contact-handled alpha-waste	· Wastewater sludge and treatment residue · Dry active waste · Residues from compaction · Construction debris · Soil · Radioactive scrap metal · Uranium oxide · Classified waste

*Type B waste will not be shipped by rail. See also Sect. 4.2.2 and definition of Type B waste in Sect. 7.0 for an explanation.

DOE = U.S. Department of Energy
ETTP = East Tennessee Technology Park
LLW = low-level (radioactive) waste
ORNL = Oak Ridge National Laboratory

ORR = Oak Ridge Reservation
PPE = personal protective equipment
yd = yard

LLW originating from former site operations primarily contains depleted uranium, enriched uranium, and technetium. However, since being shut down, ETTP has become a centralized storage facility for legacy LLW and low-level mixed waste generated at the Y-12 National Security Complex and ORNL. Therefore, some LLW stored at ETTP may contain a range of radionuclides.

2.2.2 Oak Ridge National Laboratory

ORNL was built in 1943 as part of the World War II Manhattan Project. Its original mission was to produce and chemically separate the first gram quantities of plutonium as part of the national effort to produce the atomic bomb. Today, ORNL is a basic and applied research facility funded by DOE Office of Science and other programs. Technology development is also a major focus of the Laboratory's mission today.

Principal elements of ORNL's mission include activities in energy production and conservation technologies, physical and life sciences, scientific and technological user facilities, environmental protection and waste management, science and technology transfer, and education. LLW is generated from a variety of activities resulting in multiple radionuclides, including but not limited to ^{137}Cs, ^{60}Co, ^{90}Sr, ^{7}Be, ^{233}U, and Eu.

2.2.3 Y-12 National Security Complex

The Y-12 National Security Complex (formerly known as the Oak Ridge Y-12 Plant) was constructed in the 1940s as part of the Manhattan Project to produce enriched uranium by the electromagnetic separation process. The plant evolved to a highly sophisticated weapons component manufacturing and development engineering facility. The current mission includes production of complex components and assemblies; safe and secure storage of nuclear materials; dismantlement, disposition, evaluation, and assessment of weapon components; transfer of technology to private industry; and support of other national priorities. The DOE Office of Defense Programs has operations and landlord responsibility for the Complex.

The Complex generates a variety of LLW, primarily in the form of trash, soil, construction debris, uranium oxide, classified wastes, and scrap metal. Solid LLW from the Complex may contain depleted uranium, enriched uranium, and thorium.

2.3 NO ACTION ALTERNATIVE

If the no action alternative is chosen, DOE would not ship and dispose of the existing and projected large quantities of ORR LLW at off-site radioactive waste disposal facilities. Relatively small volumes of ORR LLW would continue to be shipped to DOE or commercial disposal facilities under existing and previously approved categorical exclusions. Because no disposal facility for operational and legacy LLW is available on site, the existing and projected quantities of ORR LLW would continue to be stored on site, eventually requiring additional LLW storage facilities.

3. AFFECTED ENVIRONMENT

3.1 OAK RIDGE RESERVATION

The ORR encompasses approximately 34,500 acres of contiguous DOE land in and near the city of Oak Ridge, Tennessee. Oak Ridge residential sections and commercial parks form the northern boundary of the reservation, while the Tennessee Valley Authority Melton Hill Reservoir and Clinch River form the southern and western boundaries.

The population of a four-county region of influence (Anderson, Knox, Roane, and Loudon) is about 527,040, and includes approximately 91 percent of the labor force employed on the ORR (Bureau of the Census 1999). The city of Knoxville[1] is located about 25 miles to the east and has a population of about 169,761 (city of Knoxville, 1996 census estimate). Except for the City of Oak Ridge, the land within 10 miles of the ORR is predominantly rural and is used primarily for residences, small farms, and cattle pasture.

The climate of the region is broadly classified as humid continental. Wind speeds are less than 7.4 mph 75 percent of the time; tornadoes and winds exceeding 18.5 mph are rare. Average annual precipitation is approximately 55 in., including about 9.3 in. of snowfall. Topography of the reservation is marked by a series of northeast trending valleys and ridges, with elevations ranging from 750 to 1350 ft above sea level.

ETTP, the Y-12 Complex, and ORNL are major industrial areas on the reservation that have served a 50-year research and defense mission for DOE (see Sect. 2.2). Together, these industrial areas comprise less than 10 percent of the ORR land area.

The reservation is served by several public access roads (state Highways 95, 62, and 58), one public access secondary road, and one restricted access secondary road. Access ramps to Interstate 40 are located less than 1 mile from the southwestern and approximately 7 miles from the northeastern portions of the ORR. Rail access is available on site at ETTP and at the Y-12 Complex.

3.2 TRANSPORTATION ROUTES FROM THE ORR

LLW is transported in approved DOT, NRC, and DOE containers that meet requirements of the waste receiver. The proposed action would adhere to these requirements. If LLW was transported by commercial truck, the waste would be transported along interstate highways or other primary highways well suited to cargo-truck transport. Existing commercial rail routes and schedules are used when waste is transported by rail. The highway route characteristics from ORR to the representative treatment or disposal sites in the proposed action are provided in Table 3.1. Table 3.2 shows population along the representative routes. Table 3.3 provides the characteristics of the proposed rail routes. The total potentially exposed populations residing along the rail routes are estimated in Table 3.4.

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[1]City of Knoxville five-county metropolitan area population estimated as 659,074 (Metropolitan Planning Commission, 1994 estimate).

Table 3.1. Highway route distances from ORR to each proposed destination.

Destination	Rural distance (miles)	Suburban distance (miles)	Urban distance (miles)	Total distance (miles)
Mercury, NV	1772	212	36	2021
Clive, UT	1732	215	32	1980
Andrews, TX	1014	218	23	1256
Richland, WA	2212	257	26	2496
Aiken, SC	240	143	11	394
Kingston, TN	6	4	0	10

NV = Nevada   TX = Texas
ORR = Oak Ridge Reservation   UT = Utah
SC = South Carolina   WA = Washington
TN = Tennessee

Table 3.2. Potentially exposed populations along highway routes from ORR to each proposed destination.

Destination	Potentially exposed population*
Mercury, NV	272,791
Clive, UT	248,140
Andrews, TX	216,804
Richland, WA	252,716
Aiken, SC	120,551
Kingston, TN	700

*Derived using population densities along highway links for persons within 0.5 mi on either side of the road (source: Highway 3.4 code).

mi = mile   TN = Tennessee
NV = Nevada   TX = Texas
ORR = Oak Ridge Reservation   UT = Utah
SC = South Carolina   WA = Washington

Table 3.3. Rail route distances from ORR to each proposed destination

Destination	Rural distance (miles)	Suburban distance (miles)	Urban distance (miles)	Total distance (miles)
Clive, UT	1837	169	36	2042
Andrews, TX	1063	271	32	1367
Richland, WA	2381	190	34	2605
Proposed Caliente, NV intermodal site	2082	172	36	2290

NV = Nevada   UT = Utah
ORR = Oak Ridge Reservation   WA = Washington
TX = Texas

3.2.1 Truck Routes from ORR to Disposal Sites

Representative highway transportation routes between ORR and five disposal destinations are outlined in Figs. 3.1 through 3.5. Routing was determined in accordance with DOT requirements and using "Highway 5.0," a computer program specifically designed to identify routing to minimize risks and meet regulatory requirements (Johnson 1992b). The route to Kingston, Tennessee, outlined in Table 3.5, serves as a representative route to any of several commercial treatment facilities in the Oak Ridge area. LLW treated at these facilities would generally continue on for disposal to one of the destinations in Figs 3.1 through 3.5 or to other DOE-approved facilities.

Table 3.4. Potentially exposed populations along railway routes from ORR to each proposed destination.

Destination	Potentially exposed population*
Clive, UT	253,158
Andrews, TX	303,175
Richland, WA	255,517
Proposed Caliente, NV intermodal site	256,300

*Derived using population densities along railway links (source: Interline 5.0 code).

NV = Nevada	UT = Utah
ORR = Oak Ridge Reservation	WA = Washington
TX = Texas	

Table 3.5. Example highway route from ORR to Kingston, Tennessee, area.

Roadway	From	To	Distance (miles)	Cumulative distance (miles)
Local	ORR	Bear Creek Road and SR 95	1.2	1.2
SR 95	Bear Creek Road	SR 58	1.9	1.9
SR 58	SR 58 and 95	I-40 exit 356 (Kingston area)	6.9	9.9

ORR = Oak Ridge Reservation
SR = State Route

Fig. 3.1 Representative route for transportation of LLW by truck from Oak Ridge, Tennessee to Mercury, Nevada

ROADWAY	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Local	Oak Ridge Reservation	Bear Creek Rd. & SR95	1	1
SR95	Bear Creek Road	I-40 Exit 364	5	6
I-40	I-40 Exit 364	Nashville, TN	152	158
I-40	Nashville, TN	Needles, CA	1800	1900
US95	Needles, CA	Mercury, NV	160	2090
Local	Mercury, NV	NTS Site	6	2095

Fig. 3.2 Representative route for transportation of LLW by truck from Oak Ridge, Tennessee to Clive, Utah
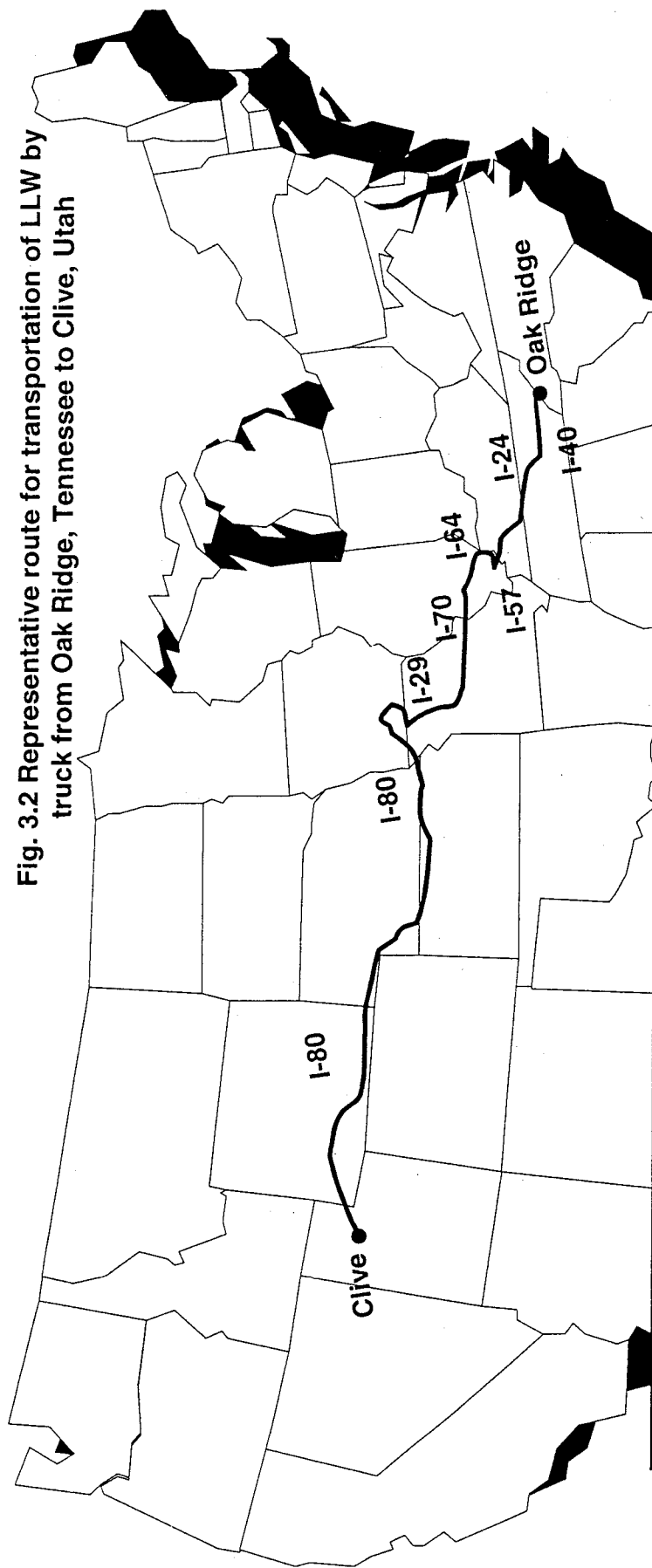
ROADWAY	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Local	Oak Ridge Reservation	Bear Creek Rd. & SR95	1	1
SR95	Bear Creek Road	I-40 Exit 364	5	6
I-40	I-40 Exit 364	Nashville, TN	152	158
I-24	Nashville, TN	Pulleys Mill, IL	186	344
I-57	Pulleys Mill, IL	Mt. Vernon, IL	53	397
I-64	Mt. Vernon, IL	St. Louis, MO	67	464
I-70	St. Louis, MO	Kansas City, MO	285	749
I-29	Kansas City, MO	Council Bluffs, IA	157	906
I-80	Council Bluffs, IA	Aragonite, UT	1064	1970
Local	Aragonite, UT	Clive, UT	9	1980

Fig. 3.3 Representative route for transportation of LLW by truck from Oak Ridge, Tennessee to Andrews, Texas
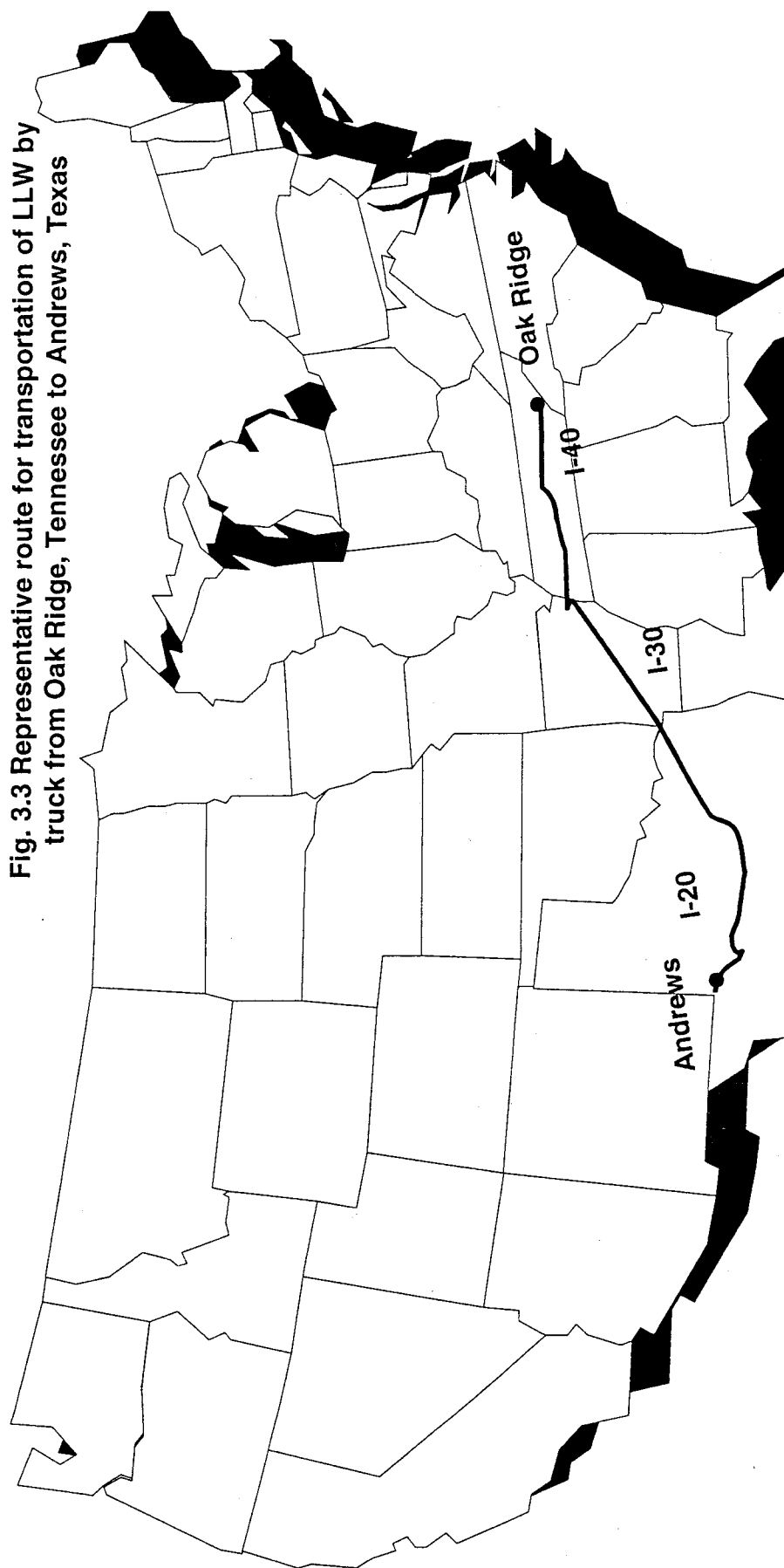
ROADWAY	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Local	Oak Ridge Reservation	Bear Creek Rd. & SR95	1	1
SR95	Bear Creek Road	I-40 Exit 364	5	6
I-40	I-40 Exit 364	Nashville, TN	152	158
I-40	Nashville, TN	Little Rock, AR	353	511
I-30	Little Rock, AR	Garland, TX	304	815
I-20	Garland, TX	Odessa, TX	373	1188
US385	Odessa, TX	Andrews, TX	38	1226
S176	Andrews, TX	WCS Site	30	1256

3-6

Fig. 3.4 Representative route for transportation of LLW by truck from Oak Ridge, Tennessee to Richland, Washington
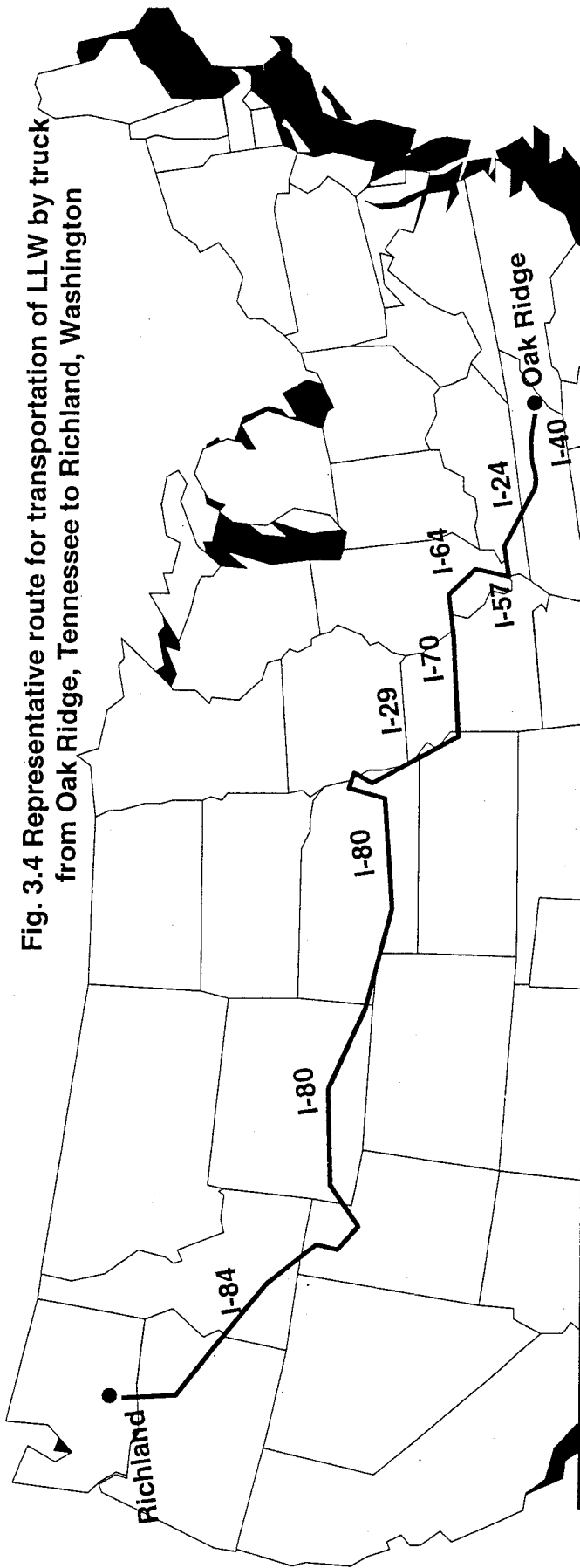
ROADWAY	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Local	Oak Ridge Reservation	Bear Creek Rd. & SR95	1	1
SR95	Bear Creek Road	I-40 Exit 364	5	6
I-40	I-40 Exit 364	Nashville, TN	152	158
I-25	Nashville, TN	Pulleys Mill, IL	186	344
I-57	Pulleys Mill, IL	Mt. Vernon, IL	53	397
I-64	Mt. Vernon, IL	St. Louis, MO	67	464
I-70	St. Louis, MO	Kansas City, MO	285	749
I-29	Kansas City, MO	Council Bluffs, IA	157	906
I-80	Council Bluffs, IA	Echo, UT	943	1849
I-84	Echo, UT	Hermiston, OR	590	2438
I-82	Hermiston, OR	West Richland, WA	41	2479
I-182/S240	West Richland, WA	Richland, WA	12	2491
LR4S	Richland, WA	Hanford area	4	2496

Fig. 3.5 Representative route for transportation of LLW by truck from Oak Ridge, Tennessee to Aiken, South Carolina

ROADWAY	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Local	Oak Ridge Reservation	Bear Creek Rd. & SR95	1	1
SR95	Bear Creek Road	I-40 Exit 364	5	6
I-40	I-40 Exit 364	Loudon Co., TN	4	10
I-75	Loudon Co., TN	Atlanta, GA	202	212
I-20	Atlanta, GA	Aiken, SC	155	367
SR19	Aiken, SC	New Ellenton, SC	18	385
Local	New Ellenton, SC	Aiken, SC (SRS area)	9	394
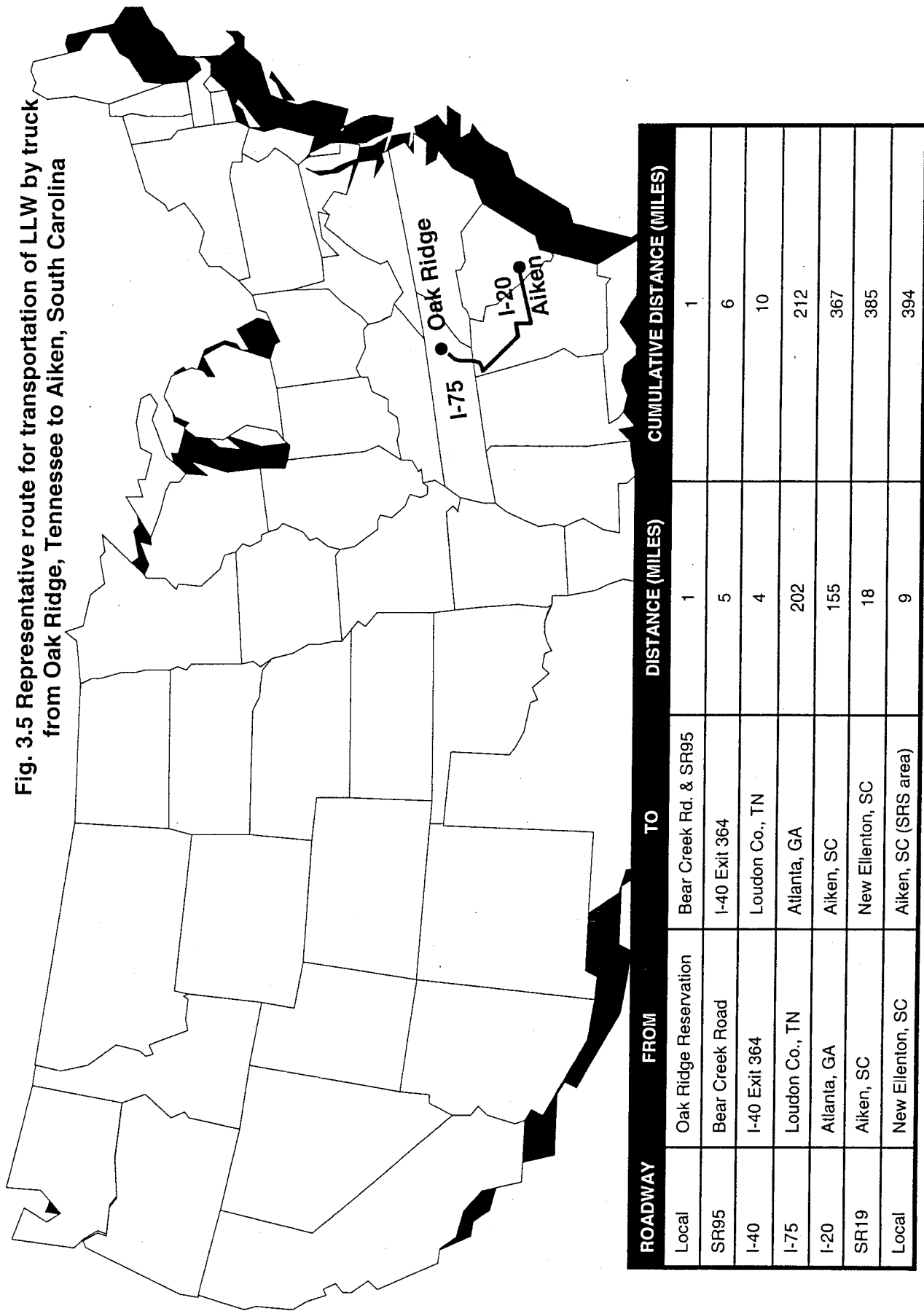
Fig. 3.6 Representative route for transportation of LLW by rail from Oak Ridge, Tennessee to Clive, Utah
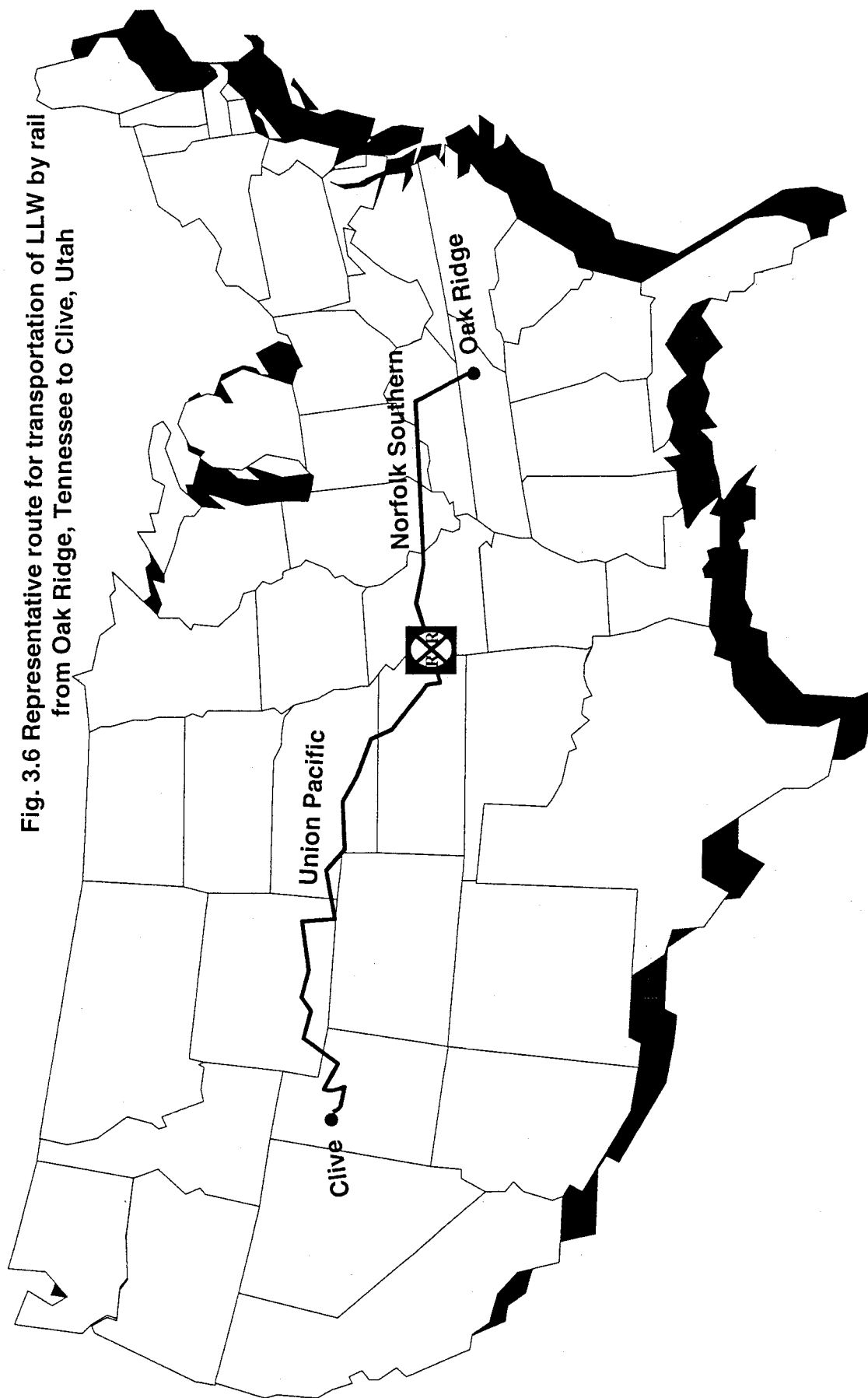
RAILROAD	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Norfolk Southern	ORR ETTP	Kansas City, MO	832	832
Union Pacific	Kansas City, MO	Clive, UT	1210	2042

3-9

Fig. 3.7 Representative route for transportation of LLW by rail from Oak Ridge, Tennessee to Andrews, Texas
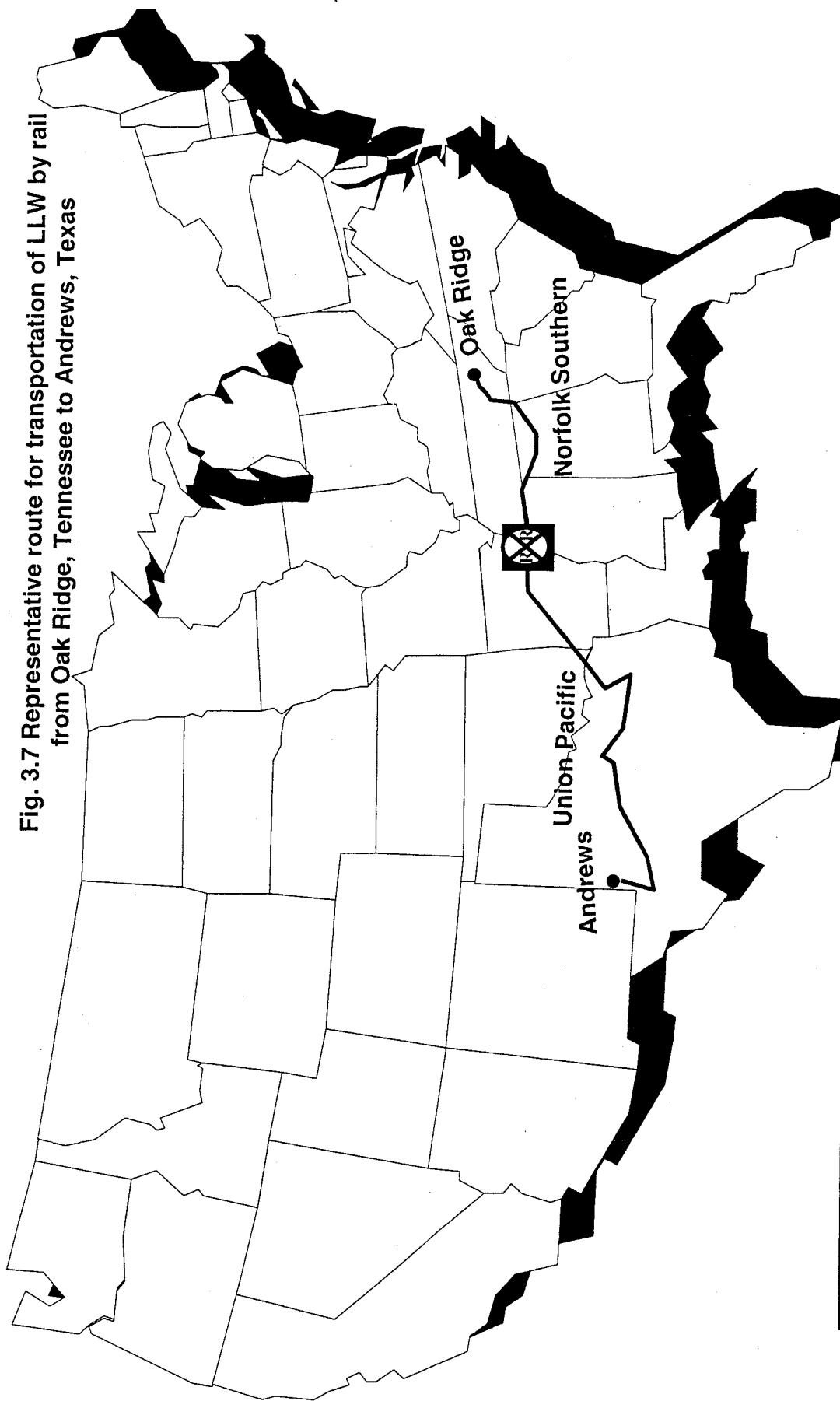
RAILROAD	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Norfolk Southern	ORR ETTP	Forrest Yard, TN	391	391
Union Pacific	Forrest Yard, TN	Monahans, TX	905	1297
TNER	Monahans, TX	Hobbs, NM	70	1367

Fig. 3.8 Representative route for transportation of LLW by rail from Oak Ridge, Tennessee to Hanford, Washington

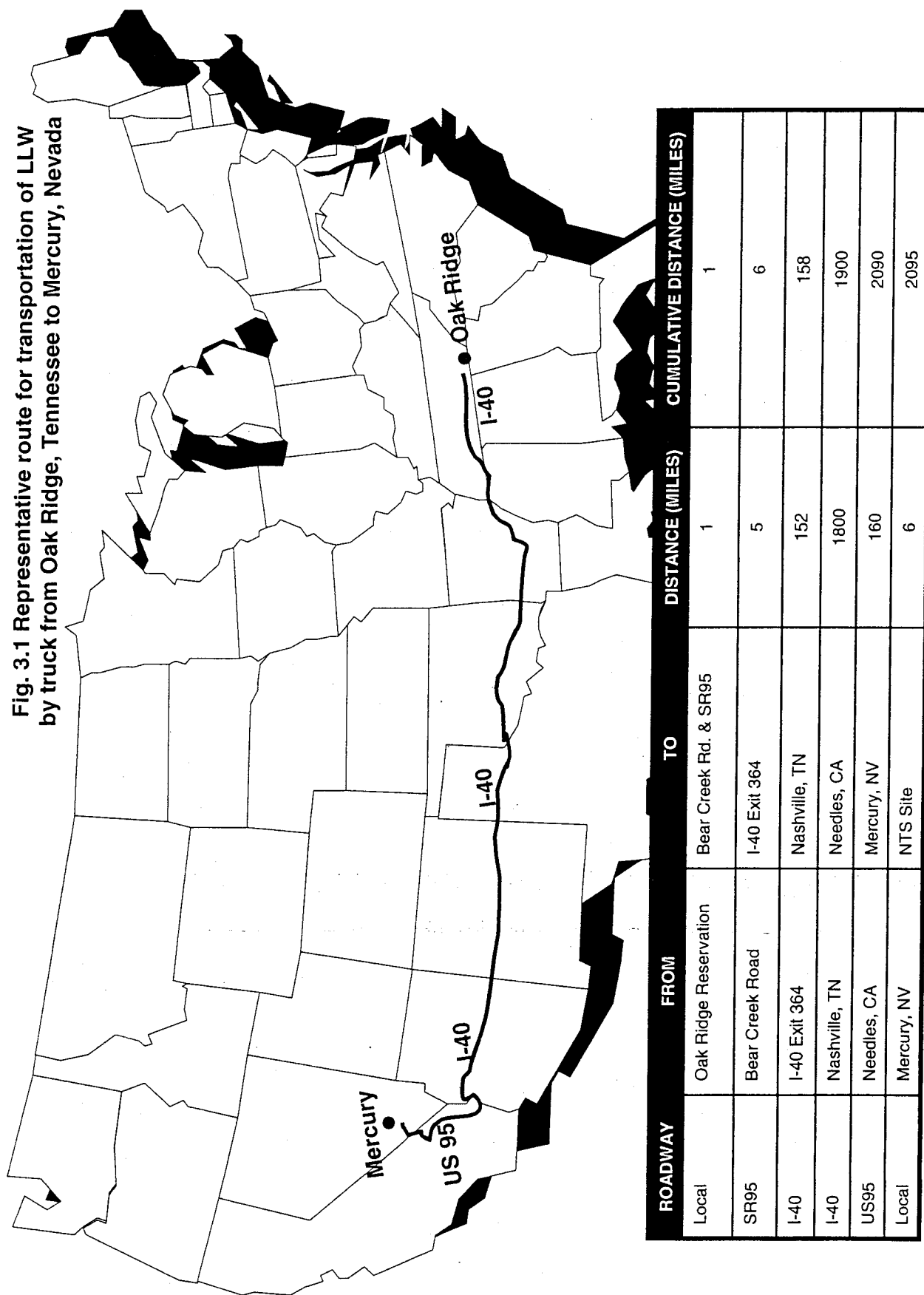| RAILROAD	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Norfolk Southern	ORR ETTP	Kansas City, MO	832	832
Union Pacific	Kansas City, MO	Richland, WA	1765	2597
USG	Richland, WA	Hanford area	8	2605
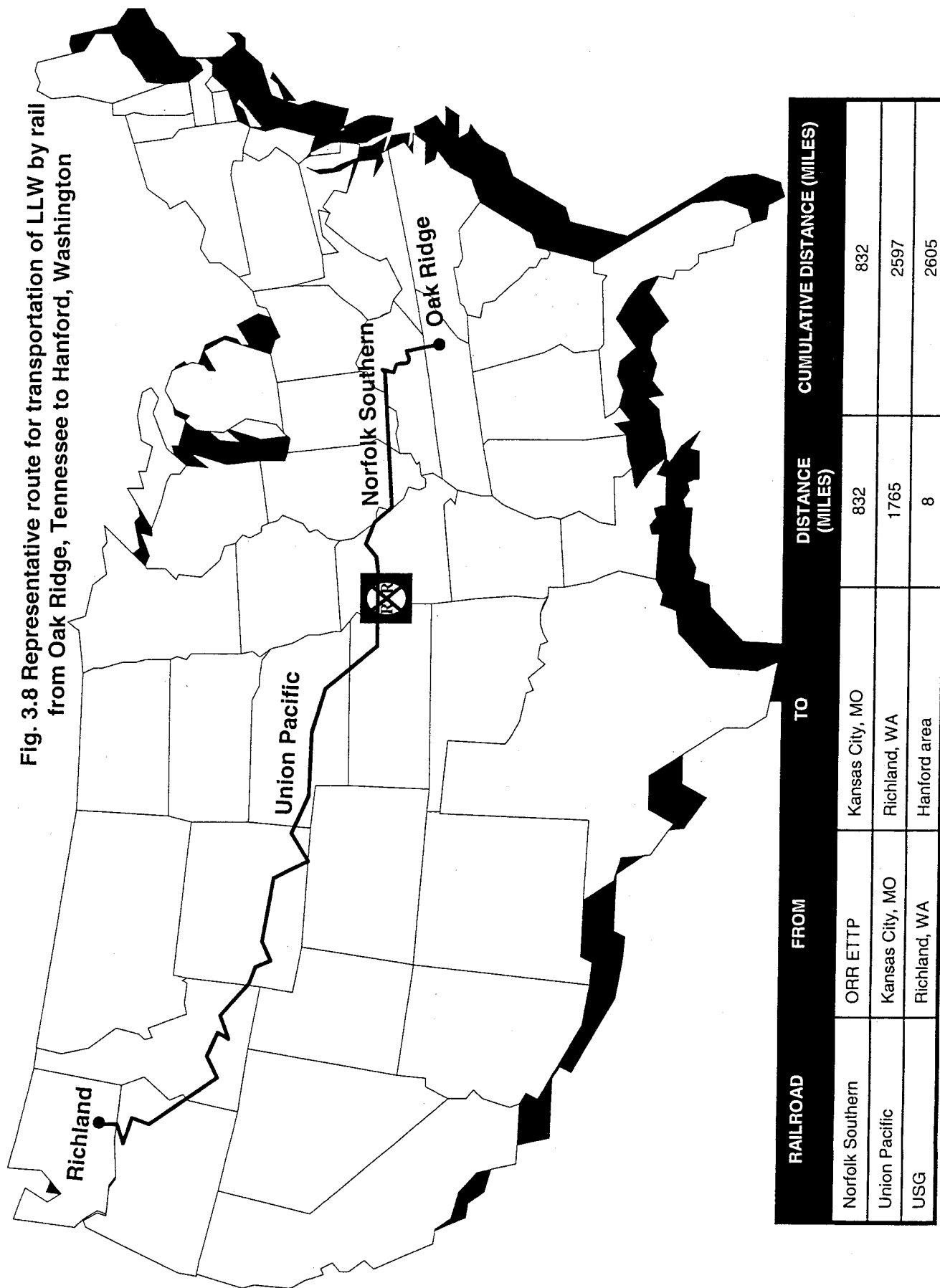
Fig. 3.9 Representative route for transportation of LLW by rail from Oak Ridge, Tennessee to Caliente, Nevada
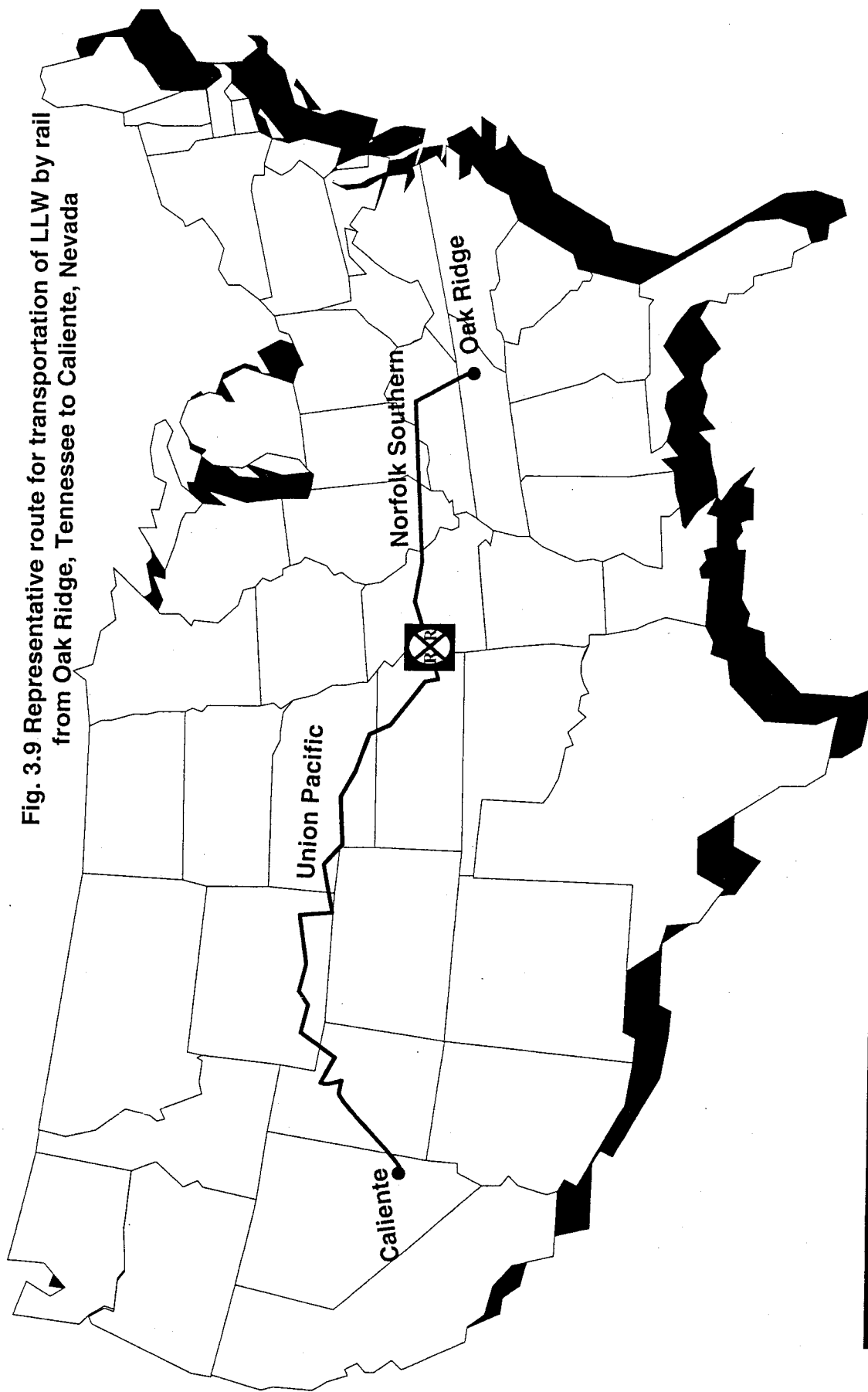
RAILROAD	FROM	TO	DISTANCE (MILES)	CUMULATIVE DISTANCE (MILES)
Norfolk Southern	ORR ETTP	Kansas City, MO	832	832
Union Pacific	Kansas City, MO	Caliente, NV	1458	2290

4. ENVIRONMENTAL IMPACTS

4.1 OVERVIEW

The proposal to transport LLW off site for disposal has been designed in a manner consistent with the requirements of DOE Order 435.1, "Radioactive Waste Management," as well as applicable federal, state, and local requirements. The procedures for preparing LLW for shipment and transport, although not evaluated in this assessment, would be designed to meet the radiation protection standards and environmental protection standards (chemical hazards) as established in DOE Order 5480.11, "Radiation Protection for Occupational Workers"; DOE Order 5400.5, "Radiation Protection of the Public and the Environment"; P.L. 91-512; and waste acceptance criteria (WAC) for the selected disposal site.

Waste packaging requirements for LLW include DOE Order 1540.1, "Materials Transportation and Traffic Management," Title 49 CFR 173.474, "Quality Control for Construction of Packaging," and Title 49 CFR 173.475, "Quality Control Requirements Prior to Shipment of Radioactive Materials." Other sections of the DOT regulations in Title 49 govern packaging features and waste configurations related to nuclear heating, radiation level limits, and activity limits.

Additionally, waste generators are required to develop a waste certification program according to DOE Order 435.1 to ensure the appropriate WAC are met. Standards for this program derive from the American Society of Mechanical Engineers (ASME) NQA-1 Quality Assurance Program (ASME 1994) and its supplements.

This section considers potential environmental effects associated with the loading and transportation of approximately 184,000 m³ of legacy and newly generated LLW from Oak Ridge to the NTS (Mercury, Nevada); Hanford Reservation or a commercial facility near Richland, Washington; SRS or a commercial facility near Aiken, South Carolina; WCS near Andrews, Texas; commercial treatment facilities near Oak Ridge, Tennessee; or Envirocare near Clive, Utah. The purpose is to ultimately disposition LLW at appropriate disposal sites. The transportation risk analysis examines both routine and accident conditions associated with overland transport of the LLW to the disposal sites. Impacts from potential exposures to radioactivity as well as nonradiological impacts, such as those caused by truck accidents, were estimated for this assessment. Potentially affected groups of people would include state safety inspectors or disposal site inspectors, truck crews, and the public.

Subsequent parts of this section discuss development of the methods used for quantitative analysis (4.2), types of effects evaluated (4.3), potential impacts of the proposed action (4.4), and potential impacts of the "noaction" alternative (4.5).

4.2 METHODS

This environmental assessment evaluates the impacts associated with transport of LLW from the ORR to the gate of the off-site treatment or disposal facility. The methods employed to quantitatively estimate impacts associated with the proposed action were primarily derived from those used in *Environmental Assessment for Sandia National Laboratories/New Mexico Off-Site Transportation of Low-Level Radioactive Waste* (DOE 1996a), which estimated total impacts of a similar transportation

campaign. Appendix A expands the discussion of methods used in determining impacts. The following impact areas were evaluated in this environmental assessment:

- radiation exposure, including risk from accidents along the transport routes;
- traffic;
- air quality;
- noise;
- ecology;
- environmental justice; and
- cumulative effects.

The most direct highway and rail transportation routes were identified from ORR to the potential receiving destinations. To determine impacts, the effects of ORR shipments were estimated and compared to environmental and population data associated with these routes. Transportation routes and potentially exposed populations were determined using the Highway 3.4 and Interline 5.0 computer models (Johnson 1992a, 1992b). To determine radiation exposure, these data and the planned number of shipments and the characteristics of the waste being transported were loaded into the RADTRAN 4 computer model (Neuhauser and Kanipe 1993) to conduct the risk analysis under normal transportation and accident scenarios.

4.2.1 ORR Shipments to DOE Sites Addressed in Other NEPA Documents

Transportation impacts resulting from the shipment of LLW from the ORR to other DOE sites were previously assessed in the WM-PEIS (DOE 1997a) as well as the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE 1996b). The impact statement evaluated an expanded use option in which the risk of transporting waste to NTS from potential generators (including ORR) was assessed. The results of these and other studies are discussed in Sect. 4.4.4 to provide additional context for evaluation of the potential doses estimated in this assessment. To ensure consistency, the methods and assumptions used in these evaluations were reviewed as the methods for this assessment were developed.

These studies make it unnecessary to repeat previous analyses of transportation routes. However, routes and destinations that were not previously considered, those to commercial facilities and one to a potential intermodal transfer facility near Caliente, Nevada, are analyzed in this assessment. The shipment of Type B LLW from the ORR is analyzed for all sites in this EA. The current shipment schedule and waste volumes have changed since the WM-PEIS analysis was performed; the significance of these changes has been evaluated.

4.2.2 Waste Characterization and Packaging Assumptions

For the analyses in this environmental assessment, ORR LLW inventory was divided into three waste subgroups: heterogeneous LLW, radioactive scrap metal, and Type B shipments.

Heterogeneous LLW accounts for approximately 49 percent of the LLW inventory and includes waste media such as soil, construction debris, dry active waste (paper, plastic, trash), sludges, uranium oxide, nonregulated chemicals and laboratory packs, and residues produced from volume reduction of LLW. These wastes are typically packaged in 55-gal drums or 4-ft x 4-ft x 6-ft metal boxes. For purposes of shipment, some forms of this waste (e.g., soil) could also be packaged in bulk containers such as "supersaks," or shipped bulk in gondolas or other bulk-containing railcars. A small percentage of heterogeneous LLW is dispersed in a solidified monolith of concrete about 10 ft in diameter by 10-ft high. The monolith would be shipped in a Type A cask, one per truck, or by

methods that meet DOT specifications. For purposes of this assessment, all heterogeneous LLW is assumed to be packaged in 55-gal drums (a conservative estimate because with more container surface area, less waste can be shipped in a single shipment than when using other containers).

Radioactive scrap metal accounts for approximately 50 percent of current LLW inventory and includes various shapes and sizes of metal debris and equipment, primarily iron. Most of this waste currently exists as bulk scrap piles and will likely be packaged for off-site transport in 4-ft x 4-ft x 6-ft metal boxes, 8-ft x 8-ft x 20-ft metal intermodal containers, or open-topped and covered railcars. For purposes of this assessment, the assumption is that radioactive scrap metal is shipped in 8-ft x 8-ft x 20-ft metal (Sealand) containers.

LLW requiring transport as DOT Type B shipments constitutes less than 1 percent of the inventory by volume. However, this waste includes high-curie content streams such as decommissioned reactor components, activated metals, and sealed radioactive sources. This type of waste will undergo extensive analyses and packaging design before off-site shipment. All Type B packages must be shown to be capable of withstanding severe accident forces, including impact, puncture, fire, and submergence under water before they are certified for use by the NRC. Proof of this will be found in a safety analysis report for the package and will be supported by analysis, physical tests, or a combination of analysis and physical tests. Type B LLW will only be shipped by highway, not rail, because of DOT regulations.

Table 4.1 describes key shipment parameters used for this analysis.

Table 4.1 Key input parameters for analysis, ORR, Oak Ridge, Tennessee.

Waste subgroup	Heterogeneous LLW	Radiological scrap metal	Type B shipments
Containers/shipment	80 55-gal drums/truck; 16.5 m^3 300 drums/railcar; 62.4 m^3	1 8-ft x 8-ft x 20-ft metal box; 27 m^3 1 box/truck or railcar	1 6-ft x 7-ft x 10-ft cask/truck
External dose rate	1 mrem/hour* at 1 m from truck or railcar	1 mrem/hour at 1 m from truck or railcar	8 mrem/hour at 1 m from truck
Dispersability	Loose powder*	Immobile	Immobile

*Consistent with WM-PEIS assumptions.

gal = gallon
LLW = low-level (radioactive) waste
m = meter
mrem = millirem

ORR = Oak Ridge Reservation
WM-PEIS = *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997a)

4.2.3 Estimated Number of Off-Site Shipments from the ORR

Current waste forecasts from ORR generators estimate that 7700 m^3 of solid LLW will be generated annually over the next 20 years. The exact number of off-site shipments that will actually occur is unknown and largely depends on available funding. For the purposes of this environmental

assessment, an accelerated disposition case was used as the baseline where all legacy waste (40,000 m³ total) is shipped for disposal by 2006 and newly generated waste (7700 m³/year) is shipped for disposal every year as it is generated.

The annual number of truckloads to transport the waste depends on the container type and packing configuration on the truck trailer or railcar. Table 4.2 shows a high-side estimate of the number of truck shipments per year for the baseline case with a typical number of boxes or drums per shipment. Table 4.3 presents a shipment campaign for rail transport. ORR LLW will generally be transported by truck, but it may also be transported by rail or intermodal carrier (i.e., truck and rail combination) when this method is advantageous.

Table 4.2 Shipment campaign for truck transport, ORR, Oak Ridge, Tennessee.

Year	Annual volume of LLW for off-site disposal (m³)	Total number of truck shipments per year	Number of shipments by waste type per year		
			Radioactive scrap metal	Heterogeneous	Type B
1999	400	25	0	25	0
2000	5,000	313	0	313	0
2001–2005	15,700	835	240	590	5
2006–2018	7,700	431	90	340	1
Total (20 years)	184,000	10,116	2,370	7,708	38

LLW = low-level (radioactive) waste
m = meter
ORR = Oak Ridge Reservation

Table 4.3. Shipment campaign for rail transport, ORR, Oak Ridge, Tennessee.

Year	Annual volume of LLW for off-site disposal (m³)	Total number of rail shipments per year	Number of shipments by waste type per year		
			Radioactive scrap metal	Heterogeneous	Type B*
1999	400	7	0	7	None
2000	5,000	80	0	80	None
2001–2005	15,700	396	240	156	None
2006–2018	7,700	180	90	90	None
Total (20 years)	184,000	4,407	2,370	2,037	None

*Type B shipments will not be shipped by rail.

LLW = low-level (radioactive) waste
m = meter
ORR = Oak Ridge Reservation

4.3 EVALUATION OF EFFECTS

Potential direct and indirect effects would be caused by taking an action. In general, direct effects occur in the same place and at a time close to that of the action. Indirect effects are caused by the action but may not occur until a later time or at a different location than the action. Potential effects may be adverse or beneficial and include, but are not limited to, effects on human health; ecological, aesthetic, or cultural resources; and effects on socioeconomics or land use. Only those effects potentially caused by the proposed action and the no action alternative are addressed in this environmental assessment.

Potential effects that would result from an action may be evaluated qualitatively or quantitatively. These effects are addressed in proportion to their potential significance; those with the greatest potential for impact have been quantified in this assessment. The effects selected for quantitative evaluation were the (1) potential for worker exposure to radiation, (2) potential for public exposure to radiation, (3) risks to the public from exposure to vehicular air emissions, and (4) risk of an injury or fatality in a traffic accident scenario. The underlying conditions associated with these analyses are described below. Three types of potential effects—noise, environmental justice (disproportionate effects to certain populations), and ecology—were selected for qualitative evaluation.

The underlying conditions associated with the following analyses are described in more detail in Appendix A. The assumptions used for the underlying conditions, such as the frequency and length of rest stops and number of persons exposed, were taken primarily from the general RADTRAN input parameters (Neuhauser and Kanipe 1993). Specific regulatory requirements and the assumptions used in previous transportation analyses were also consulted.

Potential Exposures of Workers. Personnel routinely working with materials described by this action may receive low levels of external exposure to radiation (gamma and X rays). The dose and impact on workers during LLW storage, processing/repackaging, and shipment loading are controlled and minimized by radiation work permits, as low as reasonably achievable (ALARA) principles, facility authorization bases, and radiation control procedures. Regulations require that for personnel involved with transport of LLW (e.g., truck crews), dose rates in the cabs of tractor trucks carrying radioactive waste must be less than 2 mrem/hour (49 CFR 173.441). This rate was used as a default exposure rate for transportation crew members.

Potential Exposures of the Public. During routine transportation operations, individuals near the shipping containers could receive low levels of external exposure to radiation (gamma and X rays). Internal exposures would not occur because LLW would be contained inside the shipping containers. Following are members of the public potentially at risk from routine operations resulting from overland transportation:

- Persons along the transportation route—this group, often referred to as the off-link population, generally receives the smallest dose. Population doses to persons within 0.5 mile on each side of the transport route are estimated.

- Persons sharing the transportation route—population doses to persons in vehicles traveling in the same direction (including passing vehicles) and in the opposite direction (collectively referred to as the on-link population) are estimated, although their doses are expected to be small.

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- Persons at stops—population doses to persons along the route at fuel and rest stops, tire inspection stops, etc., are estimated. In this analysis, the stop time used for truck shipments was 60 minutes every 8 hours. Public population exposed during each stop was estimated at 25 persons, and the average exposure distance for these persons was 65 ft. For rail shipments, stops in rail yards are modeled as occurring in rail yards where the public rarely comes in close proximity to trains. Therefore, exposure during rail stops is considered insignificant and is assumed to be zero.

Air Quality. The Clean Air Act of 1972, Sect. 176 (c) requires the U.S. Environmental Protection Agency (EPA) to establish rules to ensure that federal agency actions conform to state implementation plans (SIPs). These plans are designed to eliminate or reduce the severity and number of violations of the National Ambient Air Quality Standards (NAAQS). As a result, the EPA promulgated the "General Conformity" rule (58 FR 63214-63259) in November 1993. This rule applies in areas considered "nonattainment" or "maintenance" for any of six criteria air pollutants (ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter, and lead). A nonattainment area is one in which the air quality in an area exceeds the allowable NAAQS for one or more pollutants, while a maintenance area is one that has been redesignated from nonattainment to attainment. The general conformity rule covers direct and indirect emissions of criteria pollutants caused by federal actions and which exceed the threshold emission levels shown in 40 CFR 93.153(b). Each affected state is required by Sect. 176(c) of the 1990 Clean Air Act amendments to devise a SIP, which is designed to achieve the NAAQS.

DOE has integrated the requirements of the general conformity rule with those of its NEPA process wherein, for actions not exempted, the total emissions from the proposed action are evaluated to determine whether they are above de minimus thresholds and whether they are regionally significant.

EPA has a 1-hr standard for ground-level ozone that is currently enforced. An 8-hr standard for ozone had been issued, but was revoked on May 27, 2000. Should the 8-hr standard be reinstated, additional areas including Anderson, Knox, Blount, and Sevier counties in Tennessee could become nonattainment areas (TDEC 1998).

Following are significant nonattainment areas of the transportation routes listed in Sect. 3.2:

- NTS option: Las Vegas, Nevada.

- Clive, Utah, option: St. Louis, Missouri, Kansas City, Missouri–Kansas, and Salt Lake City, Utah.

- WCS (Andrews, Texas) option: Dallas–Ft. Worth, Texas area.

- Hanford option: St. Louis, Missouri, Kansas City, Missouri–Kansas, Ogden, Utah and Boise, Idaho.

- SRS option: Atlanta, Georgia area.

- For transport to commercial treatment facilities near Oak Ridge, there are no nonattainment areas. The Knoxville–Oak Ridge area is in an attainment region where criteria air pollutants do not currently exceed standards, although ozone standards may be exceeded if the 8-hr standard is reinstated and enforced.

Noise Sources. Noise sources near ORR can be categorized into two major groups: transportation and stationary sources. Transportation sources are associated with moving vehicles that generally result in fluctuating noise levels above the ambient noise level for a short period of time. Transportation sources include aircraft, motor vehicles, and rail operations. Nonfluctuating noise levels can result from transportation sources such as a busy highway heard from a distance, which sounds like a constant low hum. Stationary noise sources are those that do not move or that move relatively short distances. Noise-level fluctuations from stationary sources are caused by operational characteristics and other factors. Stationary noise sources near the ORR include ventilation systems, air compressors, generators, power transformers, and earth-moving equipment.

On-site traffic and traffic on nearby roadways and major highways contribute to overall noise levels. Fluctuation of highway noise (over long periods of time) is associated with the time of day in which peak and off-peak traffic occurs. In addition, noise levels are influenced by vehicle type, road surface conditions (wet or dry), and exhaust systems.

Ecology. Potential effects to ecology would occur if biota and their habitat were impacted by transportation of LLW. Few direct impacts to biota or their habitat would be anticipated from the proposed action to transport LLW because existing highways would be used. Under normal conditions, no pathway for exposure to hazardous substances would be complete between the containerized LLW and biota. Opportunities for exposure to radioactivity would be negligible as the waste would be in movement along the highway corridor or at rest for no longer than one hour at a highway rest stop. Exposure of biota to the hazardous substances and radioactivity contained in the LLW could potentially occur only if an accident that released the waste from both the transport vehicle and a container were to occur.

Environmental Justice. President Clinton issued "Executive Order on Federal Actions to Address Environmental Justice in Minority and Low Income Populations" February 11, 1994. This Order requires that the relative impacts of any federal actions on minority and/or low-income populations be addressed to avoid placement of a disproportionate share of the burden of the adverse impacts of federal policies and actions on these groups. For purposes of the proposed actions in this EA, populations considered are those who live within 0.5 mile on either side of the highways where transport of LLW will occur and people using the highways and/or stopping at rest stops. The number and proportion of the minority or low-income households would likely vary along the highway routes for the proposed action.

No potential effects to the following resources or areas would be anticipated from the alternatives considered in this assessment, and they are not addressed further in this document:

- climate,
- topography,
- archaeological artifacts,
- historical resources,
- threatened and endangered species, and
- economic effects.

Climate, topography, and cultural resources would not be affected because the proposed action does not involve excavation or construction activities or disturb previously undisturbed areas. Threatened and endangered species and water resources are unlikely to be affected because the use of existing transportation routes would not result in measurable changes to background conditions or discharges to waters along these routes during routine transport. Water quality and aquatic resources would only be directly exposed to radiation from the waste in the event of an accident involving the

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waste, or its containers, entering the water. The total distance traveled over rivers along the routes described in this assessment (2.2 miles maximum) is less than 0.01 percent of the total miles traveled (1 mile in 10,000 miles) for any route; therefore, the associated probability of any direct releases to water are extremely small. Water quality and aquatic resources could be indirectly affected if contaminated media entered water as the result of an accident. Spill response actions would either prevent or minimize this from occurring.

4.4 IMPACTS FROM THE PROPOSED ACTION

The proposed action would include shipment of heterogenous LLW and scrap metal LLW by truck and/or rail. Type B LLW may only be shipped by truck and not by rail because of regulatory limits on radioactivity inventories. This section discusses potential impacts associated with transporting approximately 184,000 m^3 of LLW from Oak Ridge. Shipments are modeled according to the transportation campaigns defined in Sect. 4.2.3. Transportation of LLW in this EA was modeled using the following shipping configurations:

- Heterogeneous LLW: 80 55-gal drums/truck (300 drums/railcar for the rail alternative).

- Scrap metal: one 8-ft x 8-ft x 20-ft-long container/truck (one container per railcar).

- Type B shipments: one Type B cask per truck (rail alternative not considered).

4.4.1 Radiological Impacts from Using Highway Transportation

The potential effects of transporting LLW by highway from Oak Ridge to each potential destination were estimated for all three waste subgroups on per shipment, annual, and 20-year life cycle bases. Tables 4.4 through 4.9 present the estimated risks of shipping the three combined LLW subgroups to each destination on annual and 20-year bases for the shipping campaign presented in Table 4.2. Although it is improbable that all LLW would be shipped to each given destination, these tables represent an upper level or conservative boundary for adverse effects that could be associated with shipments to that one destination. This was done to avoid pre-decisional bias as to which destination would be used or undue minimization of effects that might result from assuming that only part of the waste would be shipped to any one destination.

The estimated risks for each individual LLW subgroup on per [GTB2]shipment and life cycle bases for each destination are presented in the Appendix (Tables A.4 through A.6). These risks were also calculated using the conservative assumption that all shipments of each LLW subgroup would go to each destination over the life cycle.

4.4.1.1 Impacts from routine highway operations

Workers and Public. Dose and risk estimates were modeled using the RADTRAN 4 computer code (Neuhauser and Kanipe 1993) for dose assessment. The potential exposed populations along these routes are estimated from the route distances and appropriate population densities. This information is derived using the Highway 5.0 code, a routing model that computes population densities along all highway links (Johnson 1992b).

The estimated risks to the public are proportional to the total number of people potentially exposed to radiation while shipments are in transit. This potentially exposed population is estimated

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from population density categories and the distance traveled described in Sect. 3.0. The estimated risks to the public are based on a total dose across all persons within the potentially exposed population group described in Sect. 4.3 and in Appendix A.

The differences in estimated risks to the public between destinations are because of differences in the total number of potentially exposed people and do not reflect risks to an individual, but risks to a population. For example, the risks of a cancer occurrence resulting from exposure to radiation from routine (incident-free) shipments of LLW to Mercury, Nevada through a peak shipping year, 1.35 x 10^{-02} (less than one within the entire potentially exposed population) (Table 4.4), is based on a dose estimate for the entire potentially exposed population of 272,791 (Table 3.2). Similarly, the 8.00 x 10^{-02} (less than one within the entire potentially exposed population) (Table 4.7) risk of a cancer fatality resulting from exposure to radiation from all 10,116 shipments to Andrews, Texas, over 20 years is based on a dose estimate for the entire potentially exposed population of 216, 804 (Table 3.2). This collective population is described in Sect. 4.3 and also in Appendix A.

The estimated risks to workers differ between destinations due to distance of the destination from the ORR. The estimated risks from exposure to radiation for truck crew members would be directly proportional to the number of miles traveled because the same number of shipments were used to estimate the risks for each destination. These risk estimates range from a risk of a cancer occurrence of 1.74 x 10^{-03} (less than one within the entire set of crew members) to 3.40 x 10^{-01} (less than one within the entire set of crew members) for travel to Kingston, Tennessee, and Richland, Washington, respectively. These risks were calculated by summing the risks from 10,116 shipments over 20 years and do not represent risks to individuals (see Sect. 4.4.4.2).

The total risk group presented in Tables 4.4 through 4.9 is simply the sum of doses to the public and to the crew. The largest contributor to total incident-free risks is exposure of the public to radiation during rest stops, followed by exposure of the truck crew to radiation.

Maximally Exposed Individual. The maximally exposed individual (MEI) dose estimates presented in Tables 4.4 through 4.9 demonstrate the relatively low dose a single individual is likely to receive. The maximally exposed individual is a hypothetical member of the public who lives 98 ft from the highway and would be exposed to every shipment of LLW. The estimate for this potential exposure in the nonaccident scenario is very conservative.

The estimated risks of cancer occurrence and of latent cancer fatality for the MEI did not vary between destinations because this hypothetical individual is exposed to every shipment of all waste subgroups over the 20-year life cycle. In all cases, the risk of a cancer occurrence is 1.49 x 10^{-06} (about one in one million) and the risk of a latent cancer fatality is 4.37 x 10^{-07} (about four in 10 million) for the MEI (Table 4.4 through Table 4.9).

Differences between the estimated risks to the MEI between waste subgroups resulted from the difference in number of shipments between the subgroups and slight differences in risk from the subgroup waste itself. For example, in Table A.4, the MEI would have a 1.29 x 10^{-6} (about one in one million) and a 3.79 x 10^{-7} (about four in 10 million) risk of developing or dying from cancer as a result of exposures to radiological emissions from all shipments of heterogeneous LLW regardless of the destination. The MEI would have a 1.97 x 10^{-7} (about two in 10 million) and a 5.81 x 10^{-8} (about six in 100 million) risk of developing or dying from cancer as a result of exposures to radiological emissions from all shipments of scrap LLW regardless of the destination (Table A.5). The MEI risk of developing or dying from cancer as a result of exposures to radiological emissions from all shipments of Type B LLW regardless of the destination would be negligible because of the small number of shipments (six) anticipated (see Sect. 4.4.4.2).

Table 4.4. Dose/risk estimates for truck shipments to Mercury, Nevada.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	5.63E-01	7.88E-04	2.25E-04	7.04E+00	9.86E-03	2.82E-03	1.60E+01	2.23E-02	6.39E-03	8.66E+00	1.21E-02	3.46E-03	2.00E+02	2.80E-01	8.00E-02
Population[a]	6.33E-01	1.08E-03	3.16E-04	7.92E+00	1.35E-02	3.96E-03	1.80E+01	3.05E-02	8.98E-03	9.74E+00	1.66E-02	4.87E-03	2.25E+02	3.82E-01	1.12E-01
Total (incident free)[b]	1.20E+00	1.86E-03	5.41E-04	1.50E+01	2.33E-02	6.78E-03	3.39E+01	5.29E-02	1.54E-02	1.84E+01	2.87E-02	8.33E-03	4.25E+02	6.62E-01	1.92E-01
Population in accident	7.00E-04	1.19E-06	3.50E-07	8.76E-03	1.49E-05	4.38E-06	1.65E-02	2.81E-05	8.26E-06	9.52E-03	1.62E-05	4.76E-06	2.16E-01	3.67E-04	1.08E-04
Total radiological impact[c]	1.20E+00	1.86E-03	5.42E-04	1.50E+01	2.33E-02	6.78E-03	3.39E+01	5.29E-02	1.54E-02	1.84E+01	2.87E-02	8.34E-03	4.25E+02	6.63E-01	1.93E-01
Maximally exposed individual[d]	2.46E-06	4.18E-09	1.23E-09	3.08E-05	5.24E-08	1.54E-08	6.98E-05	1.19E-07	3.49E-08	3.79E-05	6.44E-08	1.89E-08	8.75E-04	1.49E-06	4.37E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]The sum for the Crew and Population risk groups.
[c]Total estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups.
[d]Maximally exposed individual for incident-free transportation.

rem = roentgen equivalent man

Table 4.5. Dose/risk estimates for truck shipments to Richland, Washington.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	6.83E-01	9.56E-04	2.73E-04	8.54E+00	1.20E-02	3.42E-03	1.94E+01	2.71E-02	7.75E-03	1.05E+01	1.47E-02	4.20E-03	2.43E+02	3.40E-01	9.71E-02
Population[a]	6.73E-01	1.14E-03	3.36E-04	8.42E+00	1.43E-02	4.21E-03	1.91E+01	3.24E-02	9.54E-03	1.04E+01	1.58E-02	4.64E-03	2.39E+02	3.83E-01	1.13E-01
Total (incident free)[b]	1.36E+00	2.10E-03	6.09E-04	1.70E+01	2.63E-02	7.63E-03	3.85E+01	5.96E-02	1.73E-02	2.09E-01	3.05E-02	8.84E-03	4.82E+02	7.22E-01	2.10E-01
Population in accident	6.85E-04	1.16E-06	3.43E-07	8.58E-03	1.46E-05	4.29E-06	1.62E-02	2.75E-05	8.08E-06	9.32E-03	1.58E-05	4.66E-06	2.11E-01	3.59E-04	1.06E-04
Total radiological impact[c]	1.36E+00	2.10E-03	6.10E-04	1.70E+01	2.63E-02	7.63E-03	3.85E+01	5.96E-02	1.73E-02	2.09E+01	3.05E-02	8.84E-03	4.82E+02	7.23E-01	2.10E-01
Maximally exposed individual[d]	2.46E-06	4.18E-09	1.23E-09	3.08E-05	5.24E-08	1.54E-08	6.98E-05	1.19E-07	3.49E-08	3.79E-05	6.44E-08	1.89E-08	8.75E-04	1.49E-06	4.37E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]The sum for the Crew and Population risk groups.
[c]Total estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups.
[d]Maximally exposed individual for incident-free transportation.

rem = roentgen equivalent man

Table 4.6. Dose/risk estimates for truck shipments to Clive, Utah.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	5.53E-01	7.74E-04	2.21E-04	6.92E+00	9.68E-03	2.77E-03	1.57E+01	2.20E-02	6.27E-03	8.50E+00	1.19E-02	3.40E-03	1.96E+02	2.75E-01	7.86E-02
Population[a]	6.03E-01	1.02E-03	3.01E-04	7.54E+00	1.28E-02	3.77E-03	1.71E+01	2.91E-02	8.55E-03	9.27E+00	1.58E-02	4.64E-03	2.14E+02	3.64E-01	1.07E-01
Total (incident-free)[b]	1.16E+00	1.80E-03	5.22E-04	1.45E+01	2.25E-02	6.54E-03	3.28E+01	5.10E-02	1.48E-02	1.78E+01	2.77E-02	8.04E-03	4.11E+02	6.39E-01	1.86E-01
Population in accident	6.45E-04	1.10E-06	3.23E-07	8.08E-03	1.37E-05	4.04E-06	1.52E-02	2.59E-05	7.61E-06	8.77E-03	1.49E-05	4.39E-06	1.99E-01	3.38E-04	9.94E-05
Total radiological impact[c]	1.16E+00	1.80E-03	5.23E-04	1.45E+01	2.25E-02	6.54E-03	3.28E+01	5.10E-02	1.48E-02	1.78E+01	2.77E-02	8.04E-03	4.11E+02	6.39E-01	1.86E-01
Maximally exposed individual[d]	2.46E-06	4.18E-09	1.23E-09	3.08E-05	5.24E-08	1.54E-08	6.98E-05	1.19E-07	3.49E-08	3.79E-05	6.44E-08	1.89E-08	8.75E-04	1.49E-06	4.37E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]The sum for the Crew and Population risk groups.
[c]Total estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups..
[d]Maximally exposed individual for incident-free transportation.
rem = roentgen equivalent man

Table 4.7. Dose/risk estimates for truck shipments to Andrews, Texas.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	3.75E-01	5.25E-04	1.50E-04	4.70E+00	6.57E-03	1.88E-03	1.06E+01	1.49E-02	4.26E-03	5.77E+00	8.08E-03	2.31E-03	1.33E+02	1.87E-01	5.33E-02
Population[a]	4.50E-01	7.65E-04	2.25E-04	5.63E+00	9.58E-03	2.82E-03	1.28E+01	2.17E-02	6.38E-03	6.92E+00	1.18E-02	3.46E-03	1.60E+02	2.72E-01	8.00E-02
Total (incident free)[b]	8.25E-01	1.29E-03	3.75E-04	1.03E+01	1.62E-02	4.70E-03	2.34E+01	3.66E-02	1.06E-02	1.27E+01	1.99E-02	5.77E-03	2.93E+02	4.59E-01	1.33E-01
Population in accident	6.10E-04	1.04E-06	3.05E-07	7.64E-03	1.30E-05	3.82E-06	1.44E-02	2.45E-05	7.20E-06	8.30E-03	1.41E-05	4.15E-06	1.88E-01	3.20E-04	9.40E-05
Total radiological impact[c]	8.26E-01	1.29E-03	3.75E-04	1.03E+01	1.62E-02	4.70E-03	2.34E+01	3.66E-02	1.06E-02	1.27E+01	1.99E-02	5.78E-03	2.93E+02	4.59E-01	1.33E-01
Maximally exposed individual[d]	2.46E-06	4.18E-09	1.23E-09	3.08E-05	5.24E-08	1.54E-08	6.98E-05	1.19E-07	3.49E-08	3.79E-05	6.44E-08	1.89E-08	8.75E-04	1.49E-06	4.37E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]The sum for the Crew and Population risk groups.
[c]Total estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups.
[d]Maximally exposed individual for incident-free transportation.

rem = roengen equivalent man

Table 4.8. Dose/risk estimates for truck shipments to Andrews, Texas.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	1.41E-01	1.98E-04	5.65E-05	1.77E+00	2.48E-03	7.07E-04	4.01E+00	5.61E-03	1.60E-03	2.17E+00	3.04E-03	8.70E-04	5.02E+01	7.03E-02	2.01E-02
Population[a]	2.06E-01	3.51E-04	1.03E-04	2.58E+00	4.39E-03	1.29E-03	5.85E+--	9.95E-03	2.93E-03	3.17E+00	5.40E-03	1.59E-03	7.33E+01	1.25E-01	3.67E-02
Total (incident free)[b]	3.48E-01	5.48E-04	1.60E-04	4.35E+00	6.87E-03	2.00E-03	9.86E+00	1.56E-02	4.53E-03	5.35E+00	8.44E-03	2.46E-03	1.24E+02	1.95E-01	5.67E-02
Population in accident	3.48E-04	5.91E-07	1.74E-07	4.35E-03	7.40E-06	2.18E-06	8.20E-03	1.39E-05	4.10E-06	4.73E-03	8.03E-06	2.36E-06	1.07E-01	1.82E-04	5.36E-05
Total radiological impact[c]	3.48E-01	5.49E-04	1.60E-04	4.36E+00	6.87E-03	2.00E-03	9.87E+00	1.56E-02	4.53E-03	5.35E+00	8.45E-03	2.46E-03	1.24E+02	1.95E-01	5.68E-02
Maximally exposed individual[d]	2.46E-06	4.18E-09	1.23E-09	3.08E-05	5.24E-08	1.54E-08	6.98E-05	1.19E-07	3.49E-08	3.79E-05	6.44E-08	1.89E-08	8.75E-04	1.49E-06	4.37E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]The sum for the Crew and Population risk groups.
[c]Total estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups..
[d]Maximally exposed individual for incident-free transportation.

rem = roentgen equivalent man

Table 4.9. Dose/risk estimates for truck shipments to Kingston, Tennessee.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	3.50E-03	4.90E-06	1.40E-06	4.38E-02	6.13E-05	1.75E-05	9.93E-02	1.39E-04	3.97E-05	5.39E-02	7.54E-05	2.15E-05	1.24E+00	1.74E-03	4.98E-04
Population[a]	3.45E-03	5.87E-06	1.73E-06	4.32E-02	7.34E-05	2.16E-05	9.79E-02	1.66E-04	4.89E-05	5.31E-02	9.02E-05	2.65E-05	1.23E+00	2.08E-03	6.13E-04
Total (incident free)[b]	6.95E-03	1.08E-05	3.13E-06	8.70E-02	1.35E-04	3.91E-05	1.97E-01	3.05E-04	8.86E-05	1.07E-01	1.66E-04	4.81E-05	2.47E+00	3.83E-03	1.11E-03
Population in accident	2.07E-06	3.51E-09	1.03E-09	2.59E-05	4.40E-08	1.29E-08	4.87E-05	8.28E-08	2.44E-08	2.81E-05	4.77E-08	1.40E-08	6.37E-04	1.08E-06	3.18E-07
Total radiological impact[c]	6.95E-03	1.08E-05	3.13E-06	8.70E-02	1.35E-04	3.91E-05	1.97E-01	3.05E-04	8.87E-05	1.07E-01	1.66E-04	4.81E-05	2.47E+00	3.83E-03	1.11E-03
Maximally exposed individual[d]	2.46E-06	4.18E-09	1.23E-09	3.08E-05	5.24E-08	1.54E-08	6.98E-05	1.19E-07	3.49E-08	3.79E-05	6.44E-08	1.89E-08	8.75E-04	1.49E-06	4.37E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]Total estimated radiological impacts from incident-free transport and accidents.
[c]Maximally exposed individual for incident-free transportation.

rem = roentgen equivalent man

4.4.1.2 Risks from highway accidents

As can be seen from the "Population in Accident" risk estimates in Tables 4.4 through 4.9, truck transportation risks associated with shipping waste to Hanford, NTS, WCS, and Envirocare are higher than shipping waste to SRS and Kingston, Tennessee. The risks also vary according to the distance waste must be shipped and the size of the potentially exposed population living along the transportation route modeled in the RADTRAN risk assessment. The annual risk estimates are calculated by generating route-specific risk assessments per truck shipment with RADTRAN 4 and multiplying the number of shipments per year by the risk associated with each shipment.

4.4.2   Radiological Impacts from Using Rail Transportation

The potential effects of transporting LLW by rail from Oak Ridge to each potential destination were estimated for the heterogeneous and scrap waste subgroups on per shipment, annual, and 20-year life cycle bases. As discussed in Sect. 4.2.2, a variety of containers were used for analytical purposes; to bound the potential risk from accidents, transportation of LLW in this environmental assessment was modeled for the shipping configurations of 300 drums/railcar for heterogeneous LLW and 8-ft x 8-ft x 20-ft-long metal containers for radioactive scrap metal.

Tables 4.10 through 4.13 present the estimated risks of shipping the two LLW subgroups to each destination on an annual and a 20-year basis for the shipping campaign presented in Table 4.3. As for highway transport, life cycle estimates were calculated based on shipment of all LLW (except Type B LLW) to each given destination. Thus, each of these tables represents an upper level or conservative boundary for adverse effects that could be associated with shipments to that one destination. This was done to avoid predecisional bias as to which destination would be used or undue minimization of effects that might result from assuming that only part of a waste subgroup would be shipped to any one destination.

The estimated risks for heterogeneous LLW and for scrap LLW on per shipment and life cycle bases for each destination are presented in Appendix A (Tables A.4 and A.5). These risks were also calculated using the conservative assumption that all shipments of each LLW subgroup would go to each destination over the life cycle.

4.4.2.1 Impacts from routine rail operations

Considerations Specific to the Caliente Destination. The rail route from Oak Ridge to NTS would involve an intermodal transfer of LLW from rail to truck at Caliente, Nevada. For the rail option, this assessment only addresses the route from Oak Ridge to Caliente, Nevada, and not the intermodal transport from Caliente to NTS. The highway transfer from Caliente to NTS was previously evaluated in *Intermodal Transportation of Low-Level Radioactive Waste to the Nevada Test Site Environmental Assessment* (DOE 1998). Caliente was used as the intermodal transfer point for purposes of this assessment.

The estimated risks resulting from incident-free shipments of LLW using rail transportation are presented in Tables 4.10 through 4.13. These risks were calculated using the same basic methods as the highway analyses. Rail routes (Figs. 3.6 through 3.10), estimates of the potentially exposed populations (Table 3.4), and assumptions for underlying conditions are specific to rail transportation.

Workers and Public. The estimated risks to the public are proportional to the total number of people potentially exposed to radiation while shipments are in transit. This potentially exposed population is estimated from population density categories and the distance traveled described in

Sect. 3.0. The estimated risks to the public are based on a total dose across all persons within the potentially exposed population group that is described in Sect. 4.3 and Appendix A.

The differences in estimated risks to the public between destinations are because of differences in the total number of potentially exposed people and do not reflect risks to an individual but risks to a population. For example, the risks of a cancer occurrence from exposure to radiation from routine (incident-free) shipment of LLW to Richland, Washington, through a peak shipping year, 6.31×10^{-01} (less than one within the entire potentially exposed population) (Table 4.10) is based on a dose estimate for the entire potentially exposed population of 255,517 (Table 3.4). Similarly, the 3.38×10^{-03} (less than one within the entire potentially exposed population) (Table 4.12) risks of a cancer fatality resulting from exposure to radiation from all 4407 shipments to Clive, Utah, over 20 years is based on a dose estimate for the entire potentially exposed population of 253,158 (Table 3.4). This collective population is described in Sect. 4.3 and also in Appendix A.

The estimated risks to workers differ between destinations because of the distance of the destination from the ORR. The estimated risks from exposure to radiation for rail crew members would be directly proportional to the number of miles traveled because the same number of shipments were used to estimate the risks for each destination. These risk estimates range from a risk of a cancer occurrence of 1.67×10^{-02} (less than one within the entire set of crew members) to 3.18×10^{-02} (less than one within the entire set of crew members) for travel to Andrews, Texas, and Richland, Washington, respectively. The fact that these risks were calculated by summing the risks from all 4407 shipments over 20 years, and do not represent risks to individuals, is noteworthy. (see Sect. 4.4.4.2).

The total risk group presented in Tables 4.10 through 4.13 is simply the sum of doses to the public and to the crew. The largest contributor to total incident-free risks is exposure of the crew to radiation.

Table 4.10. Dose/risk estimates for rail shipments to Richland, Washington.

Risk group	1999			2000			2001—2005			2006—2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	4.28E-02	6.00E-05	1.71E-05	4.90E-01	6.85E-04	1.96E-04	1.99E+00	2.79E-03	7.97E-04	9.40E-01	1.32E-03	3.76E-04	2.27E+01	3.18E-02	9.08E-03
Population[a]	1.60E-02	2.73E-05	8.02E-06	1.83E-01	3.11E-04	9.16E-05	6.31E-01	1.07E-03	3.15E-04	3.09E-01	5.25E-04	1.54E-04	7.37E+00	1.25E-02	3.68E-03
Total (incident free)[b]	5.89E-02	8.72E-05	2.52E-05	6.73E-01	9.97E-04	2.87E-04	2.62E+00	3.86E-03	1.11E-03	1.25E+00	1.84E-03	5.30E-04	3.01E+01	4.43E-02	1.28E-02
Population in accident	6.24E-04	1.06E-06	3.12E-07	7.14E-03	1.21E-05	3.57E-06	1.39E-02	2.37E-05	6.96E-06	8.03E-03	1.36E-05	4.01E-06	1.82E-01	3.09E-04	9.09E-05
Total radiological impact[c]	5.95E-02	8.83E-05	2.55E-05	6.80E-01	1.01E-03	2.91E-04	2.64E+00	3.88E-03	1.12E-03	1.26E+00	1.85E-03	5.34E-04	3.03E-01	4.46E-02	1.29E-02
Maximally exposed individual[d]	6.89E-07	1.17E-09	3.44E-10	7.87E-06	1.34E-08	3.94E-09	2.71E-05	4.61E-08	1.36E-08	1.33E-05	2.26E-08	6.63E-09	3.17E-04	5.38E-07	1.58E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]The sum for the Crew and Population risk groups.
[c]Total estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups..
[d]Maximally exposed individual for incident-free transportation.

rem = roentgen equivalent man

Table 4.11. Dose/risk estimates for rail shipments to Caliente, Nevada.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	3.77E-02	5.27E-05	1.51E-05	4.30E-01	6.03E-04	1.72E-04	1.75E+00	2.45E-03	7.01E-04	8.26E-01	1.16E-03	3.30E-04	2.00E+01	2.80E-02	7.99E-03
Population[a]	1.53E-02	2.59E-05	7.63E-06	1.74E-01	2.96E-04	8.72E-05	5.99E-01	1.02E-03	3.00E-04	2.93E-01	4.99E-04	1.47E-04	7.00E+00	1.19E-02	3.50E-03
Total (incident free)[b]	5.29E-02	7.87E-05	2.27E-05	6.05E-01	8.99E-04	2.59E-04	2.35E+00	3.47E-03	1.00E-03	1.12E+00	1.66E-03	4.77E-04	2.70E+01	3.99E-02	1.15E-02
Population in accident	6.35E-04	1.08E-06	3.17E-07	7.26E-03	1.23E-05	3.63E-06	1.41E-02	2.41E-05	7.07E-06	8.16E-03	1.39E-05	4.08E-06	1.85E-01	3.14E-04	9.24E-05
Total Radiological Impact[c]	5.36E-02	7.97E-05	2.30E-05	6.12E-01	9.11E-04	2.63E-04	2.36E+00	3.49E-03	1.01E-03	1.13E+00	1.67E-03	4.81E-04	2.72E+01	4.02E-02	1.16E-02
Maximally exposed individual[d]	6.89E-07	1.17E-09	3.44E-10	7.87E-06	1.34E-08	3.94E-09	2.71E-05	4.61E-08	1.36E-08	1.33E-05	2.26E-08	6.63E-09	3.17E-04	5.38E-07	1.58E-07

...cludes population dose for receptors off-link, on-link, and at stops.
...e sum for the Crew and Population risk groups.
...tal estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups..
...aximally exposed individual for incident-free transportation.

= roentgen equivalent man

Table 4.12. Dose/risk estimates for rail shipments to Clive, Utah.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	3.37E-02	4.71E-05	1.35E-05	3.85E-01	5.39E-04	1.54E-04	1.56E+00	2.19E-03	6.26E-04	7.38E-01	1.03E-03	2.95E-04	1.78E+01	2.50E-02	7.13E-03
Population[a]	1.47E-02	2.50E-05	7.35E-06	1.68E-01	2.86E-04	8.40E-05	5.80E-01	9.85E-04	2.90E-04	2.84E-01	4.82E-04	1.42E-04	6.77E+00	1.15E-02	3.38E-03
Total (incident free)[b]	4.84E-02	7.21E-05	2.08E-05	5.53E-01	8.24E-04	2.38E-04	2.14E+00	3.17E-03	9.15E-04	1.02E+00	1.52E-03	4.37E-04	2.46E+01	3.65E-02	1.05E-02
Population in accident	6.27E-04	1.07E-06	3.14E-07	7.17E-03	1.22E-05	3.58E-06	1.40E-02	2.38E-05	6.99E-06	8.06E-03	1.37E-05	4.03E-06	1.83E-01	3.10E-04	9.13E-05
Total radiological impact[c]	4.90E-02	7.32E-05	2.11E-05	5.60E-01	8.37E-04	2.42E-04	2.16E+00	3.20E-03	9.22E-04	1.03E+00	1.53E-03	4.41E-04	2.48E+01	3.68E-02	1.06E-02
Maximally exposed individual[d]	6.89E-07	1.17E-09	3.44E-10	7.87E-06	1.34E-08	3.94E-09	2.71E-05	4.61E-08	1.36E-08	1.33E-05	2.26E-08	6.63E-09	3.17E-04	5.38E-07	1.58E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]The sum for the Crew and Population risk groups.
[c]Total estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups..
[d]Maximally exposed individual for incident-free transportation.

rem = roentgen equivalent man

Table 4.13. Dose/risk estimates for rail shipments to Andrews, Texas.

Risk group	1999			2000			2001–2005			2006–2018			Total for 20-year life cycle		
	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Annual dose (person-rem)	Annual cancer incidence	Annual latent cancer fatality	Dose (person-rem)	Cancer incidence	Latent cancer fatality
Crew	2.25E-02	3.15E-05	8.99E-06	2.57E-01	3.60E-04	1.03E-04	1.05E+00	1.46E-03	4.18E-04	4.93E-01	6.90E-04	1.97E-04	1.19E+01	1.67E-02	4.77E-03
Population[a]	2.09E-02	3.56E-05	1.05E-05	2.39E-01	4.07E-04	1.20E-04	8.24E-01	1.40E-03	4.12E-04	4.03E-01	6.85E-04	2.02E-04	9.62E+00	1.64E-02	4.81E-03
Total (incident free)[b]	4.34E-02	6.70E-05	1.95E-05	4.96E-01	7.66E-04	2.22E-04	1.87E+00	2.86E-03	8.30E-04	8.96E-01	1.38E-03	3.99E-04	2.15E+01	3.30E-02	9.58E-03
Population in accident	7.77E-04	1.32E-06	3.89E-07	8.88E-03	1.51E-05	4.44E-06	1.73E-02	2.94E-05	8.66E-06	9.99E-03	1.70E-05	5.00E-06	2.26E-01	3.84E-04	1.13E-04
Total radiological impact[c]	4.42E-02	6.84E-05	1.98E-05	5.05E-01	7.81E-04	2.27E-04	1.89E+00	2.89E-03	8.39E-04	9.06E-01	1.39E-03	4.04E-04	2.18E+01	3.34E-02	9.69E-03
Maximally exposed individual[d]	6.89E-07	1.17E-09	3.44E-10	7.87E-06	1.34E-08	3.94E-09	2.71E-05	4.61E-08	1.36E-08	1.33E-05	2.26E-08	6.63E-09	3.17E-04	5.38E-07	1.58E-07

[a]Includes population dose for receptors off-link, on-link, and at stops.
[b]The sum for the Crew and Population risk groups.
[c]Total estimated radiological impacts from summing the Total (incident-free) and Population in accident risk groups.
[d]Maximally exposed individual for incident-free transportation.

rem = roentgen equivalent man

Maximally Exposed Individual. The estimated risks of cancer occurrence and of latent cancer fatality for the MEI did not vary between destinations because this hypothetical individual is exposed to every rail shipment over the 20-year life cycle. In all cases, the risk of a cancer occurrence is 5.38 x 10^{-07} (about five in 10 million) and the risk of a latent cancer fatality is 1.58 x 10^{-07} (about two in 10 million) for the MEI (Tables 4.10 through 4.13).

Differences between the estimated risks to the MEI between scrap LLW and heterogeneous LLW were because of the difference in number of shipments between the subgroups and slight differences in risk from the subgroup waste itself. For example, in Table A.4, the MEI would have a 1.29 x 10^{-06} (about one in one million) and a 3.79 x 10^{-07} (about four in 10 million) risk of developing or dying from cancer as a result of exposures to radiological emissions from all shipments of heterogeneous LLW regardless of the destination. The MEI would have a 1.97 x 10^{-7} (about two in 10 million) and a 5.81 x 10^{-8} (about six in 100 million) risk of developing or dying from cancer as a result of exposures to radiological emissions from all shipments of scrap LLW regardless of the destination (Table A.5).

DOE Nevada Operations Office selected Caliente as a likely location for developing an intermodal transfer operation. This selection was made after considering 10 potential sites for the intermodal transfer. Following site evaluation, an environmental assessment (DOE 1998) was performed. This assessment evaluated four intermodal alternatives, two at Caliente, one at Barstow, California, and one at Yermo, California. The assessment (DOE 1998) did not recommend a single alternative but analyzed risk to assist generators in making a decision. For all alternatives, that assessment found negligible adverse environmental or health impacts and no disproportionately high and adverse human health or environmental effects on minority or low-income populations resulting from the intermodal operations or the transportation to NTS.

Before being loaded on a railcar, drums shipped to Caliente, Nevada, would likely be placed in larger standardized enclosures, such as a Sealand container. These larger enclosures or containers would be loaded directly on trucks at Caliente by crane or automated loaders. This automated or mechanized method of simultaneously handling multiple drums reduces the transfer time and minimizes worker exposure.

4.4.2.2 Risks from rail accidents

As can be seen from the "Population in Accident" risk estimates in Tables 4.10 through 4.13, the accident risk associated with the option of shipping the waste by rail is roughly proportional to the distance. Risks vary according to the distance over which the waste must be shipped and the potentially exposed population living along the transportation route modeled in the RADTRAN risk assessment. The rail route distance and population data are extracted from INTERLINE 5.0, a DOE computerized rail routing model (Johnson 1992a).

4.4.3 Comparison of Radiological Impacts from Rail and Highway Alternatives

A comparison of risk estimates associated with the rail alternative to risk estimates associated with the highway alternative shows that the incident-free risk is lower for rail than for highway transport. Dose estimates for rail routes are lower primarily because the dose to persons during rail stops is negligible compared to the dose during truck stops. Rail stops are modeled as occurring at rail yards, while truck stops are modeled as occurring at public rest areas. Fewer members of the public come in close proximity to trains during stops at rail yards than at truck stops, and the risk to populations is, therefore, less. Also, there are fewer rail shipments than truck shipments, and risks are generally lower for the rail alternative.

4.4.4 Radiological Impacts—Estimated Doses Associated with the Proposed and Other Actions

Life cycle radiological impacts for the proposed action are the sum of potential impacts that could result from shipment of the total volume of waste anticipated over a 20-year life cycle.

Total radiological impacts may be calculated by adding estimated maximum annual doses from the proposed action and doses from other radioactive waste shipments occurring at the same facilities, along the same routes, and projected to occur concurrently during the same time period as the proposed action. This approach is conservative in that it neglects the fact that dose fractionation (delivery of a total dose in a number of separate doses spread over time) may reduce the effect of the lifecycle dose (Ullrich and Jernigan 1987, Miller and Howe 1989).

The following discussion focuses on the proposed action's life cycle radiological impact on workers and the public (who would be exposed as a result of the proposed action). This is then considered in the context of results of the *Final Environmental Statement on the Transportation of Radioactive Material by Air and Other Modes*, NUREG-0170 (NRC 1977) and other studies. Doses estimated from the proposed action are related to natural background radiation, estimates from NUREG-0170, and other studies.

4.4.4.1 NUREG-0170 and other studies on population exposures

The proposed action is similar in many respects to other radioactive waste transportation activities occurring in the same locations and along similar routes. NUREG-0170 (NRC 1977) considered the risk of transporting various types of packages of radioactive wastes, including shipment of spent nuclear fuel and secondary transport[2] along transportation corridors similar to those that would be used for the proposed action. NUREG-0170 used annual shipment levels from that time for the United States as a whole to obtain maximally exposed individual dose estimates. Secondary transport is the class of shipment considered in NUREG-0170 that can be used to conservatively model traffic in the Oak Ridge vicinity. NUREG-0170 estimated the dose to an individual living 98 ft from a roadway on which all secondary transport shipments pass would be 0.09 mrem. More recent studies of radioactive waste shipments indicate no substantial change has occurred in the number and characteristics of shipments that would invalidate the general result of NUREG-0170 (Weiner et al. 1991).

Using RADTRAN 4, Weiner (1991) estimated that the MEI member of the public would receive no more than 0.14 mrem if exposed to the in-transit passage of all of the approximately 1.6 million radioactive waste packages shipped in the United States in a single year. This is not a realistic scenario, but it does place an upper limit on the individual in-transit dose from other shipments.

The individual in-transit dose for a person located 98 ft from an average route segment and exposed to the average LLW traffic is approximately 0.00009 mrem (Mills and Neuhauser 1994). However, it is recognized that the number of LLW shipments that could occur annually near Oak Ridge as a result of the proposed action could exceed the average LLW traffic on U.S. roadways.

Earlier analyses in the WM-PEIS found the transportation of LLW posed very low risk to the general population. For an assumed 65,420 truck shipments over 20 years, a cumulative dose of

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[2]Secondary transport is the shipment by light-duty vehicles of consignments of a large variety of packages (Type A and small Type B packages) in cities and suburbs along secondary roadways and city streets.

1.1 mrem was estimated for the MEI (DOE 1997a). For an assumed 10,116 truck shipments, this assessment estimated a cumulative dose of 0.875 mrem to the MEI. Other documents have assessed the potential for radiological exposures from LLW transportation and found the action to present negligible risks to the public. The *Environmental Assessment for Sandia National Laboratories/New Mexico Off-Site Transportation of Low-Level Radioactive Waste* (DOE 1996a) and the *Environmental Assessment for Off-Site Transportation of Low-level Waste from Four California Sites Under the Management of the U.S. Department of Energy* (DOE 1997b) reached similar conclusions of insignificant impact. Similar results were also found in *Intermodal Transportation of Low-Level Radioactive Waste to the Nevada Test Site Environmental Assessment* (DOE 1998).

4.4.4.2 Estimated individual doses resulting from the proposed action

Public Doses. The maximally exposed individual dose estimates as presented in Tables 4.4 through 4.13 demonstrate the relatively low dose that an individual might receive from incident-free transportation (0.070 mrem during a peak year). The difference between the MEI dose estimates and dose estimates of the various population groups demonstrates the effect of population distributions on dose estimates. The MEI dose represents an estimate of the dose that would be received by the same individual if that individual were exposed to each shipment of LLW.

This dose estimate is small compared to estimates of expected exposures from background radiation. Accident rates for LLW shipments, as a group, are relatively low. Out of approximately 2,000,000 truck shipments of LLW from 1971 through 1990, there were a total of 53 accidents of any kind. Only four of these accidents resulted in any spillage and the released material was quickly cleaned up with no measurable exposure to people along the route or to response personnel (Fuchs 1996). In the United States, each person receives, on average, about one millirem per day from natural sources of radiation here on earth. Along the transportation corridors that would be used in implementing the proposed action, the average annual effective dose equivalent for a member of the population from all sources of radiation other than the proposed action is expected to be approximately 360 mrem (NAS 1990).

Worker Doses. Worker doses were estimated for conveyance crew members. The maximum total dose truck crew members would receive is 19.4 person-rem/year. Based on two crew members per truck, the dose to a single truck crew member who participated in every single shipment (835) within any particular year would be 9.7 person-rem/year. With 835 truck shipments scheduled in the year this maximum crew dose occurs, it is impossible for a single crew to participate in all shipments and thus receive this dose. It is more likely the maximum trips one crew could make is one per week, or 52/year, which would result in a dose of approximately 1.2 person-rem or 0.6 person-rem (600 mrem)/crew member. Rail conveyance crew size is also assumed to be two members. Exposure for a rail crew member is a factor of 4.6 lower using the same assumptions.

4.4.5 Nonradiological Risks from Emissions and Accidents as a Result of the Proposed Action

Loading waste onto transport vehicles at the ORR would present risks of accidents. These risks would be similar to, and not exceed, the risks already presented by ongoing operations.

Table 4.14 summarizes health effects and accident risks on an annual basis resulting from highway transportation under the proposed action. These risks are directly proportional to the total distance traveled in a year so risks are greatest for the years with the most shipments, as well as for destinations farthest from Oak Ridge. For example, the highest fatality risk is 8.49×10^{-1} (about 8 out of 10 or an 80 percent chance of a single fatality over 1.75 million miles of travel) for shipping to

Mercury, Nevada in any one year between 2001 and 2005, the destination with the most shipments anticipated within these years. This risk of a fatality from an accident is shared among all 835 shipments estimated for one year. Thus the risk of a fatality on a per shipment basis would be 1.01 x 10^{-3} (about 1 in 1000 or a tenth of a percent chance of a fatality over 2095 miles of travel). These risks of a potential accident are estimated using default rates for all types of truck shipments and are not a prediction that a fatality would occur during shipment of LLW. This is an important fact to note. The likelihood of an accident could be much lower based on the number of accidents that have occurred historically for these types of shipments (Section 4.4.4.2) and for all shipments of hazardous materials (see below). While the possibility of an accident during the transport of LLW will always exist, the additional training requirements and safety standards apply to truck drivers who transport hazardous materials may account for these historically lower than average accident rates.

The injury and fatality risks in Table 4.14 would be the result of a traffic accident only, and are not related to the contents of the shipment. These risks are the same as those from shipments using similar sized truck rigs to transport boxes of cereal or paper goods. The risk of an injury or a fatality from an accident is further shared among the entire potentially exposed population, i.e., individuals in passing cars and at rest stops and the crew, similar to the estimated risks of exposure to radiological emissions. Appendix A discusses the methods used to estimate these risks.

The rail transportation model assessed impacts of transporting Oak Ridge LLW by regularly scheduled commercial rail. As there would be no additional increase in rail traffic over the routes between Oak Ridge and the proposed disposal sites, no increase in the health effects or accident risks that exist from regularly scheduled rail traffic would occur as a result of the proposed action.

It is useful to put the risks of the proposed action and the no action alternative in perspective with other risks commonly experienced. In a study of risks from 1994 through 1998, there were 1.7 deaths for motor vehicles (equivalent to one per sixty million miles) and 2.8 deaths for large trucks per 100 million vehicular miles. During the same period, there were 1.6 deaths per million train miles (NSC 1999). There were 0.14 fatalities per million shipments of all types of hazardous materials transportation (DOT 1999).

4.4.5.1 Air quality impacts from highway transport

Section 4.3 lists major nonattainment areas associated with each highway route option. All the nonattainment areas are located along interstate highways.

The highway shipping campaign is described in Sect. 4.2.3. Over the 20-year period, 10,116 truck shipments would be required. The maximum number of truck shipments that will occur in any one year is 835 (see Table 4.2). It is expected that shipments would be spread evenly over the year; thus the maximum in any one week would be 16, or two to three/day. All major nonattainment areas are associated with large metropolitan areas. Planned shipments of two to three/day maximum would not discernibly increase the daily rate of truck traffic for these metropolitan areas, and they are minimal compared with the daily rate of truck traffic in the areas.

A brief analysis was undertaken to determine the impact of the proposed shipments relative to the threshold emission levels in nonattainment areas described by EPA in its air conformity regulations [40 CFR 93.153(b)(1)]. The EPA general conformity rule (58 FR 63214, November 30, 1993) requires federal agencies to prepare a written conformity analysis and determination for proposed activities only in those cases where total emissions of an activity exceed the threshold emission levels. Where it can be demonstrated that emissions from a proposed new

activity fall below the thresholds, these emissions are considered to be de minimus and require no formal analysis.

The proposed routes were evaluated for maximum road miles proposed to be traveled for each criteria pollutant. Carbon monoxide, ozone, and particulate matter smaller than 10 micrometers (PM_{10}) were the criteria pollutants used. The maximum road miles traveled through a nonattainment area would be approximately 150 miles (includes return trip) through the Dallas-Ft. Worth, Texas, area (Atlanta and St. Louis areas are nearly as large). This distance conservatively includes a return truck trip even though the return trip is not part of the Oak Ridge proposed action (no LLW on the truck), and it is likely that commercial vehicles would not return to Oak Ridge by the same route if they were able to contract a load for the return trip.

Table 4.14. Health effects and accident risks for highway transport.

Year	Disposal site option	Annual incident-free effects from vehicle emissions All population groups (LCF)	Annual traffic accidents Injuries	Fatalities
1999	Richland, WA	3.32E-04	4.88E-01	3.90E-02
	Clive, UT	4.14E-04	2.93E-01	2.41E-02
	Mercury, NV	4.69E-04	2.31E-01	2.54E-02
	Andrews, TX	2.97E-04	6.51E-02	7.08E-03
	Aiken, SC	1.43E-04	2.20E-02	2.17E-03
2000	Richland, WA	4.16E-03	6.10E+00	4.88E-01
	Clive, UT	5.19E-03	3.67E+00	3.02E-01
	Mercury, NV	5.87E-03	2.89E+00	3.18E-01
	Andrews, TX	3.72E-03	8.1E-01	8.87E-02
	Aiken, SC	1.79E-03	2.75E-01	2.72E-02
2001–2005	Richland, WA	1.11E-02	1.63E+01	1.30E+00
	Clive, UT	1.38E-02	9.80E+00	8.05E-01
	Mercury, NV	1.56E-02	7.70E+00	8.49E-01
	Andrews, TX	9.93E-03	2.17E+00	2.37E-01
	Aiken, SC	4.77E-03	7.34E-01	7.25E-02
2006–2018	Richland, WA	5.73E-03	8.41E+00	6.72E-01
	Clive, UT	7.15E-03	5.06E+00	4.15E-01
	Mercury, NV	8.08E-03	3.97E+00	4.38E-01
	Andrews, TX	5.13E-03	1.12E+00	1.22E-01
	Aiken, SC	2.46E-03	3.79E-01	3.74E-02

LCF = latent cancer fatality   TX = Texas
NV = Nevada   UT = Utah
SC = South Carolina   WA = Washington

The EPA threshold for carbon monoxide for all nonattainment and maintenance areas is 200,000 lb (100 tons)/year for any new proposed activity. The EPA threshold for ozone (measured by its precursor, NO_x for "ozone attainment areas outside an ozone transport region" such as Dallas–Ft. Worth) is 200,000 lb (100 tons)/year. The EPA threshold for PM_{10} for all moderate nonattainment areas is 200,000 lb (100 tons)/year for any new proposed activity. Emission factors for carbon monoxide and ozone for various motor vehicle types have been modeled for the year 1990 (Goel 1991). Emission factors for PM_{10} have been calculated using EPA's February 1995 model for that criteria pollutant. Heavy duty diesel-powered vehicles (HDDVs) are defined as any diesel-powered motor vehicle designated primarily for the transportation of property and rated at more than 8500 lb of gross vehicle weight. For HDDVs, including the standard commercial semitractor vehicles that would be used for pulling waste shipments, the average emission for carbon monoxide is estimated as 11.03 g/mile, while the NO_x (an ozone precursor) emission rate is 22.91 g/mile. Finally, the emission factor for PM_{10} is 14.87 g/mile.

Using a maximum of 835 shipments (truck round trips)/year, the carbon monoxide emission rate was estimated for the maximum distance traveled through a nonattainment area (Dallas–Ft. Worth). This emission rate was approximately 3047 lb of carbon monoxide/year. This amount of emissions is below the threshold standard of 100 tons/year and is clearly a de minimus amount.

Using a maximum of 835 shipments/year (truck round trips), an ozone emission rate was established for the maximum distance traveled within a nonattainment area (Dallas–Ft. Worth area). This emission rate was approximately 6313 lb of NO_x/year (NO_x is a precursor to ozone). This amount of emissions is below the threshold standard of 100 tons/year and clearly a de minimus amount.

Finally, using 835 shipments/year, a PM_{10} rule was established for the maximum distance within a nonattainment area (Dallas–Ft. Worth). The emission rate was 4102 lb of PM_{10}/year. This amount is below the threshold standard of 100 tons/year and clearly a de minimus amount.

Because the Dallas–Ft. Worth area example maximizes road miles traveled through a nonattainment area and also conservatively estimates emission factors, it is assumed that this example "bounds" the impacts within other nonattainment areas for the proposed action. Therefore, air emissions within all nonattainment and potential nonattainment areas along shipment routes are well below the EPA threshold emission levels, and thus require no formal conformity analysis.

4.4.5.2 Noise impacts from the proposed action

Because the dominant noise source along the route is from the passage of vehicles, the issue is whether the proposed transportation shipping campaign would significantly increase traffic flow and noise level. Even if the assumed shipment rates were increased several times above the anticipated maximum of two to three/day, no noticeable change in common highway noise along any part of the routes would be expected between ORR and NTS, Hanford, Envirocare, SRS, the surrounding ORR area, or WCS.

No increases in noise levels or frequency would be anticipated from rail transportation because regularly scheduled commercial trains would be used.

4.4.5.3 Ecological impacts from the proposed action

As mentioned in Sect. 4.3, exposure of biota to the hazardous substances and radioactivity contained in the LLW could potentially occur if an accident that released the waste from both the transport vehicle and a container were to occur. If such an accident were to occur, emergency spill response measures would be immediately initiated. Every effort would be made to recover all of the waste and any contaminated media. Most of the waste sub-groups are solids and are not readily dispersable by wind. If biota were exposed to the LLW under these circumstances, the effects would be localized and temporary. Such effects could have adverse effects on individual organisms, but would not affect populations of organisms.

4.4.5.4 Environmental justice impacts from the proposed action

The dominant risk associated with incident-free transportation of LLW by highway is the exposure of the public to radiation at rest stops followed by exposure of truck crews. These exposures are put into perspective by comparison to a hypothetical MEI dose estimate (i.e., an individual who would be exposed to each shipment of LLW). As discussed in Sect. 4.4.4.2, the MEI estimate is small compared to estimates of expected exposures from background radiation. Estimated risk of cancer resulting from vehicle emissions that would be contributed by the LLW transportation program are also low (Table 4.14). Estimated risks resulting from transportation by rail are as low or lower than from highway transportation.

Individual access and use of public highways or rest stops that would be used by trucks shipping LLW is not limited or restricted to any particular population group, economically disadvantaged or advantaged. Similarly, access to and use of railways are open to the public, although safety considerations within rail yards would often limit where the general public might approach a train. Although it is expected that the percentage of the total population comprised of minority or low-income households would vary along the rail and highway routes for the proposed action, the impacts from LLW shipments are estimated to be negligible. There is, therefore, no disproportionate adverse impact to those minority or low-income households along the routes. These groups would be subject to the same negligible impacts as the general population.

4.4.6 Irreversible and Irretrievable Commitment of Resources

Irreversible and irretrievable commitments of resources include resource loss (such as burning of fossil fuel) and foregone resources (i.e., resources that would remain but would be inaccessible or could not be used, such as land used for building construction). Implementation of the proposed action will result in the irreversible and irretrievable use of necessary fuel, oil, and tires for transport and some transport packaging materials for the waste. The majority of waste, however, will be transported and disposed of in the packaging used for storage.

4.4.7 Cumulative Effects

Cumulative effects are defined as "... the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or nonfederal) or person undertakes such other actions" (40 CFR 1508.7). Effects are considered on a cumulative basis because significant effects are often the result of individually minor direct and indirect effects of multiple actions that occur over time. Cumulative effects should be considered over the "lifetime" of the effects, rather than the duration of the action. The no action alternative is typically included as a baseline against which cumulative effects are evaluated.

The most noteworthy potential adverse effects that would occur from the proposed action include risk of exposure to radiation, risk of traffic accident, and risk from air emissions. These risks for adverse effects have been quantified in Sects. 4.4.1, 4.4.2, and 4.4.5.1. Other actions with similar potential effects could act synergistically or additively with the above risks, thereby increasing these adverse effects cumulatively. The potential for radiation exposure is transient, existing only for the time an individual is in close enough proximity to the radioactive waste for the radioactive emissions to pass through the packaging and reach them. The total risks from exposure to radiation from all shipments of LLW over the next 20 years have been estimated for the proposed action. A cumulative effect from this exposure would occur only if the same individual has received, or receives, radiation exposures from other actions.

Cumulative risks to workers from exposure to radiation are no more likely under the proposed action than risks under the no action alternative. Worker exposures will occur from stored LLW when workers monitor the waste and potentially repackage or move it for maintenance purposes. The cumulative effects for this would be bounded by regulatory ceilings just as they are for transport of the waste. The potential for risks from exposure to radiation for the public would initially be less under the no action alternative because the waste would not be moved along a public roadway. However, as volumes of stored waste increase through time, the inventory of radioactivity present at ORR would increase and the potential for an accidental release could also increase.

Potential for radiation exposure from other actions is very difficult to estimate for members of the public. By law, exposure to radiation is monitored for workers such as the truck driver and crew. Regulatory limits set ceiling levels for short-term and cumulative exposure to radiation. These limits can be considered an upper bound on the cumulative effects from radiation exposure for workers, regardless of what action causes the exposure. Similarly, cumulative risks from traffic accidents would accrue with miles driven (or ridden) and are tied to the individual accruing the travel mileage rather than the specific action causing the travel.

Cumulative effects from air emissions are a problem in modern society and are the cause of our regulatory emissions and permitting programs. Certainly, transport of the waste would cause emissions of combustion products, which add incrementally to air pollution and must be minimized as much as possible. However, beneficial effects are also considered in evaluation of cumulative effects. If the proposed action is taken, new storage areas for LLW will not be constructed on ORR, and less monitoring will be required. Emissions from motor vehicles used to travel to and around storage sites will decrease, and emissions from equipment used to construct new storage areas will not be required. These emissions would result from the no action alternative.

4.5 IMPACTS FROM THE NO ACTION ALTERNATIVE

Under the no action alternative, the majority of LLW accumulated and generated at the ORR would continue to be managed in storage. DOE would not ship and dispose of the existing and projected volumes of waste at off-site disposal facilities for radioactive waste. Relatively small volumes of LLW would continue to be shipped to DOE or licensed commercial disposal facilities under existing , previously approved categorical exclusions. The stored waste would continue to be inspected, repackaged, staged, and transported on site as required to maintain it. As additional waste is generated, additional storage facilities would be required.

The no action alternative is typically used as a baseline for evaluation of effects for action alternatives. However, the no action alternative also causes effects as described in this section, and these effects contribute to other similar effects at the ORR on an incremental basis. Storage and management activities for LLW, such as expenditures for fuel and other materials, produce air emissions and noise and cost money. These effects are added to those of the other waste management and environmental restoration activities on the ORR. Storage buildings must be maintained, enlarged, and replaced as necessary to ensure the safety of workers and the public. Construction of new storage facilities could represent a commitment of land for this purpose. If the no action alternative were selected and construction of a new facility was required at a later date, it would be subject to NEPA review as a proposed action at that time.

The most important aspect of the no action alternative is that continued storage of LLW on site at the ORR cannot be equated with permanent disposal. Ultimately, LLW would still require disposal.

4.5.1 Potential Exposure of Workers to Radiological Emissions

Workers are exposed to radiological emissions in the course of conducting waste management activities at the ORR. These activities include, but are not limited to, routine inspections of storage areas to identify deteriorating or leaking containers and to verify inventories, placement of new waste, replacement of labels degraded by exposure to sun and inclement weather, repackaging of waste as containers degrade, checking radiation monitors, and replacement of warning signs. If a leak or spill does occur, workers in the immediate area and responding personnel may receive doses of radiation that would vary according to the nature and extent of the spill.

Exposures to radiation contribute incrementally to cancer risks for workers; these risks are reported annually for the ORR as a whole in the Annual Site Environmental Report (ASER) (DOE 1999b). Activities associated with the management of LLW are a subset of these risks that result from all activities at the ORR. According to the annual report, risks are well within acceptable levels; thus, on an annual basis, the same can be inferred about risks from LLW. Storage of the same waste inventories over time would result in an increase in handling of the waste for repackaging, etc. While risks to an individual would not necessarily increase, the number of workers exposed to the waste and the resulting cumulative dose to the worker population would likely increase. As the volume of stored waste increased over time, the associated risks of managing the waste would also increase on a cumulative population basis.

Overall risks to individual workers are kept as low as possible in accordance with DOE Orders and the principles of "as low as reasonably achievable." Steps taken to keep worker exposures as low as possible include limiting the time employees spend in each storage area, monitoring all worker exposure to avoid exceeding established dose limits, prohibiting storage of liquids in outdoor storage

areas, ensuring that all emergency equipment is properly maintained, and minimizing the amount of radioactive waste generated at Oak Ridge.

4.5.2 Potential Exposure of the Public to Radiological Emissions

Opportunities for public exposure to radiological emissions resulting from storage of LLW at the ORR are limited during routine waste management activities. Since radiological emissions have a rapid "drop off" rate over both time and distance, airborne emissions from LLW would not routinely reach ORR boundaries. A perimeter monitoring program and warning system are in place around plant boundaries and elsewhere at the ORR. There are regulatory limitations for off-site radiological emissions as well. Environmental media, such as soil and water, have the potential to become contaminated and subsequently migrate off site during storm events. These risks are minimized through safety programs and personnel training. The ASER (DOE 1999b) also provides information on radiological emissions that could affect the public, and these risks have been negligible.

Members of the public could potentially be exposed to radiological emissions from LLW during waste management activities in the event of a spill, accident, or lapse in adherence to safety protocols. For example, if rainwater infiltrated a container of waste and it subsequently leaked while being moved from one storage location to another, radiological releases could occur. Such releases could accumulate in the surrounding environment and be a source of both direct and indirect exposures. Every effort would be made to clean up any releases completely if an accident happened.

As with the potential for worker exposure to radiological releases, the risks are a subset of risks from all radiological sources at the ORR that fell below negligible levels (DOE 1999; NCRP 1993), and risks from current inventories of LLW are quite low. However, increases in inventory volume would contribute incrementally to risks to the public.

4.5.3 Nonradiological Risks from Accidents as a Result of the No Action Alternative

There are risks from accidents during routine waste management activities, just as there are for any type of physical activity. Slips, trips, and falls may occur. Workers can be injured by improper lifting or accidents with equipment. These risks generally increase with the increase in the number of workers that would be required for the no action alternative. These risks are minimized through safety standards and worker training on the ORR as at other industrial facilities. Continued storage of LLW under the no action alternative would increase these safety risks by requiring additional handling of the same waste as repackaging and facility maintenance is required.

As waste inventories increase over time, storage facilities would need to be expanded, and new facilities would have to be constructed. This would require the use of heavy equipment and introduce accident risks during facility construction.

4.5.4 Air Quality Impacts from the No Action Alternative

Waste management activities result in emissions from motor vehicles and building utilities. The ORR is currently in an attainment region, and emissions from LLW management activities would be below threshold levels and therefore, de minimus. However, air quality is evaluated on a regional basis, and the greater Oak Ridge/Knoxville area as well as the Great Smoky Mountains National Park have had some days when ozone levels exceeded thresholds. The emissions from Oak Ridge contribute incrementally to ozone levels on a regional basis and should therefore be minimized wherever possible.

4.5.5 Noise Impacts from the No Action Alternative

The no action alternative would not alter noise levels on the ORR since the activities that would be conducted under this alternative are already being conducted. If construction of new storage facilities were required, noise levels in the vicinity of the construction would increase during the construction period.

4.5.6 Ecological Impacts from the No Action Alternative

Potential radiological impacts resulting from the no action alternative on local ecological systems would be continued exposures of biota on the ORR to some radioactivity. Storage of LLW would be a relatively small portion of the total exposure ORR biota receive because the majority of the waste is containerized and stored in buildings or storage yards that provide little habitat for plants and animals. Biota inhabiting or visiting the ORR may be exposed to both radioactivity and hazardous substances (e.g., leachate from uncontainerized scrap metal). A biological monitoring and abatement program issues reports on contaminant levels and their effects on local biota. The majority of these effects are caused by contamination originating from past activities and operations on the ORR, but LLW stored on the ORR also contributes to these effects.

Construction of new storage facilities for LLW would increase noise and dust levels during construction. This could affect local animal populations, particularly during breeding seasons. Mitigation would be required to minimize erosion and sedimentation of surface water during construction as well. Overall, these effects would likely be temporary and localized.

4.5.7 Environmental Justice Impacts from the No Action Alternative

Risks to the public as a result of the no action alternative would be similar in nature and location to current risks from LLW that are at negligible levels and spread throughout the ORR. It is unlikely that minority or low-income populations would be disproportionately affected by the risks from the no action alternative. Most risks associated with the no action alternative are risks to workers from exposure to radiological emissions and accidents. The ORR worker population is not composed of a disproportionate percentage of minorities or low-income populations.

4.5.8 Irreversible and Irretrievable Commitment of Resources

The no action alternative would result in the irreversible and irretrievable use of necessary fuel, power, and materials for maintaining the packaging integrity of the waste and the buildings and areas used for storing the waste as well as for meeting reporting and monitoring requirements. If new storage facilities were constructed, additional building materials and energy would be used. Additional funding would be required for managing increasing volumes of LLW and for construction of new facilities.

4.5.9 Cumulative Effects from the No Action Alternative

Implementation of the no action alternative would add incrementally to current risks for exposure of workers and the public and local biota to radiological emissions because it would increase the amount of LLW present on the ORR. Additional resources would be needed to manage on-site waste.

5. PERSONS AND AGENCIES CONTACTED

Comments received from persons and agencies contacted are listed in Appendix B. DOE's responses are also provided.

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7. GLOSSARY

Absorbed dose

The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest. The unit of absorbed dose is the rad.

Activity

See "Radioactivity."

Average annual daily traffic

The total number of vehicles traveling in one direction on a defined road segment per year divided by 365. If multiple counts exist for an area, the smallest count is reported in this EA. This procedure helps ensure a conservative estimate of the impacts of the proposed action on local vehicle traffic and vehicle emissions.

Biological dose

See "Dose conversion factor."

Characterization

A term applied to waste and to the procedure by which it is sampled, categorized, and labeled before processing, storage, or transport.

Ci, μCi, nCi

Curie, microcurie, and nanocurie; special unit of radioactivity. One Ci is 3.7 $\square$ 10^{10} nuclear transformations/second. One μCi equals 10^{-6} Ci, while one nCi equals 10^{-9} Ci.

Committed dose equivalent

Dose equivalent is the product of absorbed dose measured in rad (or measured in gray [Gy]) in tissue and a quality factor. It is expressed in units of rem or sievert. Committed dose equivalent is the predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose.

Committed effective dose equivalent

The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. It is expressed in units of rem (or sievert).

Compaction

Reduction of waste volumes by hydraulic press, in the cases where such reduction would not itself cause a hazard.

Decibel

(1) The unit for the measurement of the intensity of sound, one decibel representing the faintest sound that can be heard by the human ear. (2) The unit that expresses the difference in power between two acoustic

	or electric signals, equal to one-tenth the common logarithm of the ratio of the two levels.
Decontamination	The removal of unwanted material (typically radioactive material) from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other techniques.
Dose	The quantity of radiation absorbed, per unit mass, by the body or by any portion of the body (10 CFR 20.4[a]).
Dose conversion factor	Frequently used as the factor that expresses the committed effective dose equivalent to a person from the intake (inhalation or ingestion) of a unit activity of a given radionuclide.
Dose equivalent	The product of absorbed dose in tissue, a quality factor, and other modifying factors. Absorbed dose (expressed in units of rad) is the energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. A quality factor is the principal modifying factor used to calculate the dose equivalent from the absorbed dose. Dose equivalent is expressed in units of rem.
Dose rate	The radiation dose delivered per unit of time measured, for example, in rem per hour.
Effects	Synonymous with "Impacts." Includes ecological, aesthetic, historic, cultural, economic, social, or health impacts, whether direct, indirect, or cumulative. Under NEPA, the effects of beneficial as well as detrimental actions must be considered.
Environmental restoration	Measures taken to clean up and stabilize or restore a site contaminated with hazardous substances.
Gamma rays	Electromagnetic radiation emitted in the process of nuclear transformation or radioactive decay.
General public	The general populace. Does not include radiation workers.
Generator	Any person, by site location, whose act or process produces hazardous waste identified or listed in 40 CFR 261 (RCRA Sects. 144.2; 146.3; 270.2).
Hazardous material	Any substance or material that poses an unreasonable risk to health, safety, and/or property.
Impacts	See "Effects."

Latent cancer fatality	A fatal malignancy that may occur after 10 years or more and that has a probability of occurrence that increases with exposure.
Low-level (radioactive) waste (LLW)	Waste that contains radioactivity and is not classified as high-level waste, transuranic waste, or spent nuclear fuel, or by-product material. Test specimens of fissionable material irradiated for research and development may be regarded as LLW only if the concentration of transuranics is less than 100 nCi/g.
Maximally exposed individual	An individual member of the public who is modeled as living beside the highway route and who is exposed to every shipment at a distance of 98 ft.
Mixed waste	Waste containing both hazardous (chemically toxic) and radioactive components.
Neutron generator	A piece of equipment that enhances a nuclear chain reaction in a nuclear warhead through the electrical acceleration of ions onto a target of fissionable material.
Nonattainment area	Geographic area that does not meet one or more of the National Ambient Air Quality Standards for the criteria pollutants designated in the Clean Air Act.
Off site	Anything, such as roads, buildings, streams, and people, located outside or beyond the restricted public access boundaries. Any site that is not on site.
Particle accelerator	A device that accelerates electrically charged atomic or subatomic particles, such as electrons, protons, or ions, to high energies. Also known as accelerator (Parker, ed., 1989).
Person-rem	Unit of estimating dose from radiation exposure to a population. Equal to the average individual dose times the number of people in the population exposed.
Population dose	Population dose is expressed in person-rem and is used in estimating possible effects to a human population exposed to known hazardous materials, such as radioactivity. Equal to the average individual dose (in rems) times the number of people exposed.
Probability	The annual probability of occurrence of a single accident or event sequence.
Quality factor	The ratio of dose equivalent (rem or mrem) to absorbed energy (rad or mrad) is called the quality factor.

Rad	A unit of measurement for radioactivity that represents an absorbed dose equal to 100 ergs/g (0.01 J/kg) in any medium. (1) The spontaneous nuclear decay of a material with a corresponding release of energy in the form of particles and/or electromagnetic radiation. (2) The property characteristic of radioactive material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the curie (or becquerel).
Radiation worker	An individual who works with or around radiation or who, in the course of completing a task, may be exposed to radiation.
Radioactive waste	Solid, liquid, or gaseous materials of negligible economic value that contain radionuclides in excess of threshold quantities except for radioactive material from postweapons test activities.
Release fraction	The fraction of the total inventory of radioactive or hazardous particulate or vapor released to the atmosphere during an accident.
Risk	A measure of the product of the probability and the consequences of an accident expressed in either qualitative or quantitative terms.
Roentgen equivalent man (rem)	(1) Unit used to express human biological doses as a result of exposure to various types of ionizing radiation. (2) Unit of radiation that charges atoms, equal to the amount that produces the same damage to humans as 1 roentgen of high-voltage X rays. The relation of the rem to other dose units depends on the biological effect under consideration and on the conditions/type of irradiation.
Sealand	A metal container nominally 8 ft x 8 ft x 20 ft.
Site	The land area that a facility occupies. The area of land owned or controlled by DOE for the principal purpose of constructing and operating a facility and limited by the site boundary.
Transportation index (TI)	A dimensionless number (rounded up to the nearest first decimal place) displayed on the label of a package to designate the degree of control to be exercised by the carrier during transportation (10 CFR 71.4). For this EA, the TI is the number expressing the maximum radiation level in millirem per hour to be measured at 1 m from the external surface of the outermost package on a conveyance.

Type B low-level waste	Type B low-level radioactive waste refers to LLW that has characteristics that trigger DOT "Type B" regulatory requirements for packaging and shipping of radioactive materials (49 CFR 173). In general, these requirements are triggered when materials' radioactivity levels exceed certain levels on a per mass basis or in isotopic combinations. The ensuing DOT requirements set limits on allowable mass per package for the radioactive constituents, on emission levels per package, emission levels per vehicle, and on whether the vehicle may be used to transport other cargo at the same time or must be for "exclusive use" in transporting the radioactive materials. These, and the many other requirements and restrictions that are triggered by waste falling into the Type B shipping category, make rail shipment impracticable. Thus, Type B waste is considered for shipment by truck only in this assessment.
Waste streams	Typical and average quantities of waste by category produced by a facility or an organization annually.

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APPENDIX A

RISK ASSESSMENT METHODS AND RESULTS
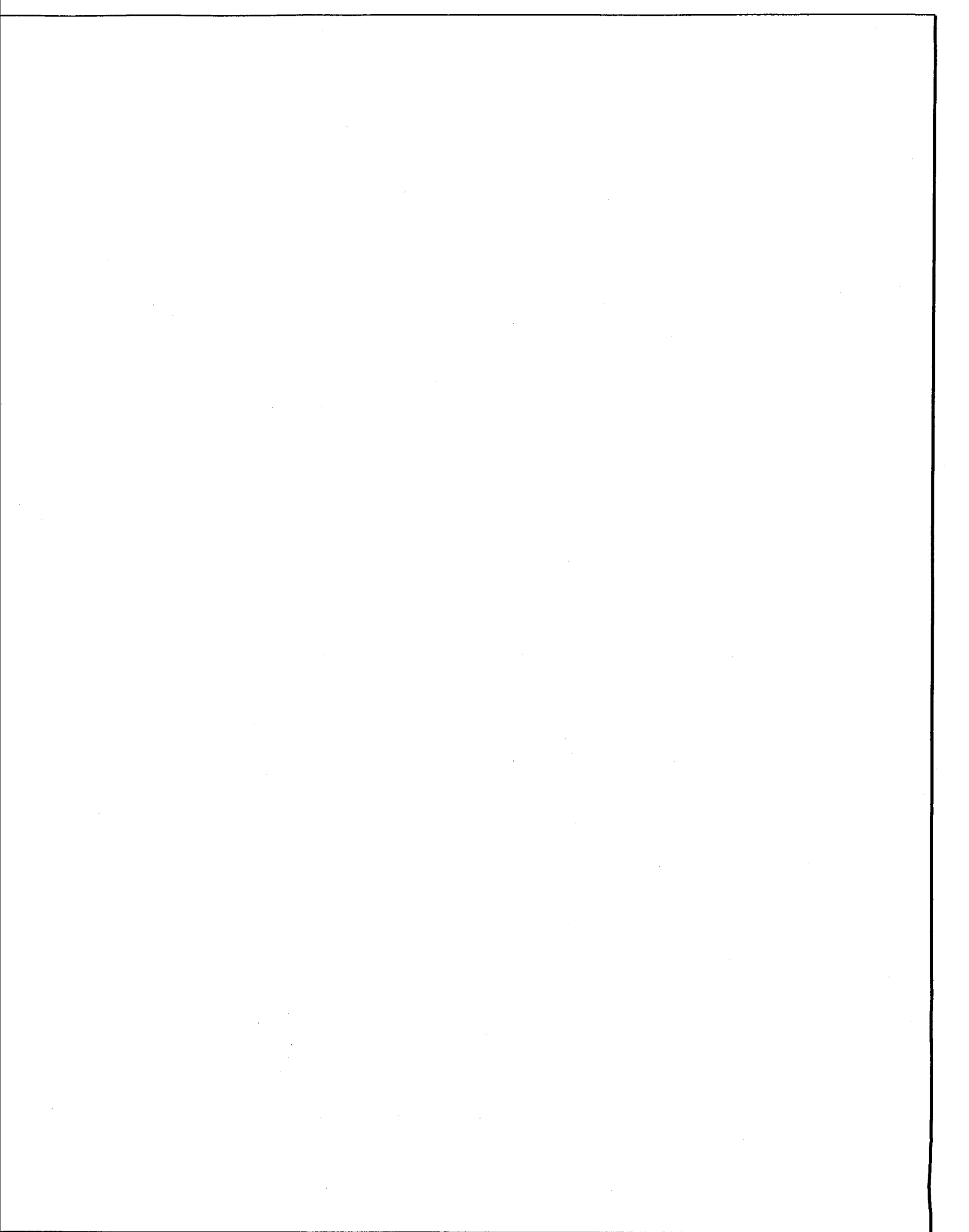
A.1 RISK ASSESSMENT METHODS

Risks related to the transportation of radioactive waste were evaluated for the following consequences: (1) excess cancer risk from exposure to gamma radiation during routine (incident-free) transportation, (2) excess cancer risk resulting from exposure to contaminants released in an accident, and (3) injury or fatality as a result of physical trauma from vehicle collisions. This evaluation addresses risks to the potentially exposed population as a group rather than a maximally exposed individual. Human health risks associated with the transportation of LLW were assessed for 27 cases. Each case represents a specific waste type, mode of transportation, and destination. Risks from exposure to radioactive material were assessed for routine transportation and accidents. For the routine assessment, risks were calculated for collective populations of potentially exposed individuals. The accident assessment consists of the following components: (1) an accident risk assessment considering probabilities and consequences of a range of possible transportation-related accidents and (2) an accident consequence assessment considering only radiological impacts of transportation-related accidents resulting in release of radioactive material.

The RADTRAN 4 computer code (Neuhauser and Kanipe 1993) was used for routine and accident risk assessments to estimate the impacts to collective populations. RADTRAN 4 was developed by Sandia National Laboratory to calculate population risks associated with transporting radioactive materials by various means, including truck, rail, air, ship, and barge. Only truck and rail transportation were evaluated quantitatively for this risk assessment.

RADTRAN 4 calculations of population risk consider consequences and probabilities of potential exposures. The collective population risk is a measure of the total radiological risk posed to society as a whole by the alternative being considered.

A.1.1 ROUTINE (INCIDENT-FREE) RISK ASSESSMENT METHOD

A.1.1.1 Collective Population Risk

Radiological risk associated with routine transportation results from potential exposure of people to low-level external radiation from loaded shipments. For routine transportation, RADTRAN 4 considers all major groups of potentially exposed persons. RADTRAN 4 calculations of risk for routine highway and rail transportation include exposures of the following population groups:

- Persons along the route (off-link population)—Collective doses were calculated for all persons living or working within 0.5 mile on each side of a transportation route. The total number of persons within the 1-mile corridor is calculated separately for each route considered.

- Persons sharing the route (on-link population)—Collective doses were calculated for persons in all vehicles sharing the transportation route. This group includes persons traveling in the same or opposite direction as the shipment as well as persons in vehicles passing the shipment.

- Persons at stops—Collective doses were calculated for people who may be exposed while a shipment is stopped en route. For truck transportation, these include stops for refueling,

food, and rest. For rail transportation, stops were assumed to occur for purposes of classification.

- Crew members—Collective doses were calculated for truck and rail transportation crew members.

Doses calculated for the first three population groups were added to yield the collective dose to the public; the dose calculated for the fourth group represents the collective dose to workers. Routine dose estimates are not intended to be used for assessing specific risks to individuals.

RADTRAN 4 calculations for routine doses are based on generic expressions of the dose rate as a function of distance from a point source. Associated with the calculation of routine doses for each exposed population group are parameters, such as the radiation field strength, source-receptor distance, duration of exposure, vehicular speed, stopping time, traffic density, and route characteristics such as population density. The RADTRAN 4 manual (Neuhauser 1993) contains derivations of equations and descriptions of these parameters. Table A.1 presents values for the most important parameters.

Collective risks for routine transportation were calculated for each case. Each case was defined as a set of origin-and-destination pairs. Representative highway and rail routes were determined for each unique pair. The number of shipments transported across each linkage was then calculated for truck and rail modes using the waste inventories and information on shipment capacity. For shipments between each origin-and-destination pair, RADTRAN was used to calculate the collective risks to workers and the public on the basis of representative radiological and physical properties of the waste type being considered.

A.1.1.2   Vehicle-Related (Nonradiological) Routine Risk

Vehicle-related health risks resulting from routine transportation may be associated with the generation of air pollutants by transportation vehicles during waste shipment. The health end point evaluated was the excess latent mortality caused by inhalation of vehicular exhaust. A risk factor for latent mortality from pollutant inhalation is 1.6×10^{-7}/mile of truck travel in an urban area. This risk factor is based on regression analyses of the effect of sulfur dioxide and particulate releases from diesel exhaust on mortality. Excess latent mortality is assumed to be equivalent to cancer fatalities. Vehicle-related risks from routine transportation were calculated for each case by multiplying the total distance traveled in urban areas by the appropriate risk factor. Similar risk factors are not available for rural and suburban areas. Risks were summed over the entire route and over all shipments for each case (Table A.2) (DOE 1997a).

A.1.2   ACCIDENT ASSESSMENT METHOD

A.1.2.1   Radiological Accident Risk Assessment

Risk analysis for potential accidents differs fundamentally from risk analysis for routine transportation because the likelihood of an accident occurring is derived from transportation industry statistics. The accident risk assessment is treated probabilistically in RADTRAN 4. Accident risk is defined as the product of the accident consequence (dose) and probability of the accident occurring. In this respect, the RADTRAN 4 code estimates collective accident risk to populations by

Table A.1. RADTRAN 4 input parameters for scrap metal LLW

Isotope	Package (Ci)	Physical/chemical group	Dispersibility category[a]
Truck and rail			
Technetium-99	1.19E-03	Solid	2 (immobile)
Uranium-235	1.19E-03	Solid	2 (immobile)
Uranium-238	4.77E-03	Solid	2 (immobile)

Release

Accident severity category	Fraction of contents released
1	0
2	1.00E-02
3	1.00E-01
4	1.00E+00
5	1.00E+00
6	1.00E+00
7	1.00E+00
8	1.00E+00

Truck

Characteristic dimension (m)	Fraction of dose	
	From gamma	From neutron
6.1	1	0

Rail

Characteristic dimension (m)	Fraction of dose	
	From gamma	From neutron
6.1	1	0

Links

Traffic speed (km/hour)	Vehicles per hour	Accidents per km	Population zone (R, S, U)[b]	Road type (1, 2, 3)[c]
88	470	1.37E-07	R	1
40	780	3.00E-06	S	1
24	2800	1.60E-05	U	1

Links

Traffic speed (km/hour)	Vehicles per hour	Accidents per km	Population zone (R, S, U)[b]	Road type (1, 2, 3)[c]
56.3	2	1.00E-07	R	3
32.2	3	1.90E-06	S	3
16.	4	1.50E-05	U	3

[a]Dispersibility category 2 is described as immobile within aerosol fraction of 1.00E-06 and arespirable fraction of 5.00E-02.
[b]R = rural, S = suburban, U = urban
[c]1 = interstate, 2 = U. S. highway, 3 = all other

Ci = curie
km = kilometer
LLW = low-level (radioactive) waste
m = meter

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Table A.2. RADTRAN 4 input parameters for shipments of heterogeneous LLW

Truck and Rail

Isotope	Drum (Ci)	Box (Ci)	Physical/chemical group	Dispersibility category	80-drum truck shipment	300-drum rail shipment
Manganese-54	5.79E-06	7.49E-05	Solid	3	4.63E-04	1.74E-03
Cobalt-58	7.2E-06	9.34E-05	Solid	3	5.78E-04	2.17E-03
Cobalt-60	3.71E-05	4.80E-04	Solid	3	2.97E-03	1.11E-02
Strontium-90	5.52E-05	7.14E-04	Solid	3	4.42E-03	1.66E-02
Technetium-99	1.00E-05	1.29E-04	Solid	3	8.00E-04	3.00E-03
Cesium-134	3.25E-06	4.21E-05	Solid	3	2.60E-04	9.75E-04
Cesium-137	5.38E-05	6.96E-04	Solid	3	4.30E-03	1.61E-02
Europium-154	1.36E-06	1.76E-05	Solid	3	1.09E-04	4.08E-04
Europium-155	3.63E-07	4.70E-06	Solid	3	2.90E-05	1.90E-04
Uranium-233	5.93E-07	7.67E-06	Solid	3	4.74E-05	1.78E-04
Uranium-235	1.88E-05	2.43E-04	Solid	3	1.50E-03	5.64E-03
Uranium-238	3.99E-04	5.16E-03	Solid	3	3.19E-02	1.20E-01
Plutonium-238	3.03E-08	3.92E-07	Solid	3	2.42E-06	9.09E-06
Plutonium-239	7.93E-08	1.03E-06	Solid	3	6.34E-06	2.38E-05
Americium-241	2.39E-05	3.09E-04	Solid	3	1.91E-03	7.17E-03
Curium-244	8.29E-08	1.07E-06	Solid	3	6.63E-06	2.49E-05

Truck

Characteristic dimension (m)	Fraction of dose	
	From gamma	From neutron
12.2	1	0

Rail

Characteristic	Fraction of dose	
	From gamma	From neutron
18.3	1	0

Table A.2 (continued)

Links

Traffic speed (km/hour)	Vehicles per hour	Accidents per km	Population zone (R, S. U)[b]	Road type (1, 2, 3)[c]
56.3	2	1.00E-07	R	3
32.2	3	1.90E-06	S	3
16.	4	1.50E-05	U	3

Fraction of accident occurrence for rail

Accident severity category	Rural	Suburban	Urban
1	3.56E-01	3.13E-01	5.72E-01
2	2.14E-01	1.88E-01	3.43E-01
3	3.85E-01	4.51E-01	7.72E-02
4	3.85E-02	4.51E-02	7.72E-03
5	6.41E-03	3.38E-03	5.14E-04
6	6.48E-04	1.63E-04	1.86E-05
7	3.42E-04	3.76E-05	8.57E-06
8	6.41E-05	3.13E-06	7.15E-07

Links

Traffic speed (km/hour)	Vehicles per hour	Accidents per km	Population zone (R, S. U)[b]	Road type (1, 2, 3)[c]
88	470E+02	1.37E-07	R	1
40	780E+02	3.00E-06	S	1
24	2800E+03	1.60E-05	U	1

Fraction of accident occurrence for truck

Accident severity category	Rural	Suburban	Urban
1	4.62E-01	4.35E-01	5.83E-01
2	3.02E-01	2.85E-01	3.82E-01
3	1.76E-01	2.21E-01	2.78E-02
4	4.03E-02	5.06E-02	6.36E-03
5	1.18E-02	6.64E-03	7.42E-04
6	6.47E-03	1.74E-03	1.46E-04
7	5.71E-04	6.72E-05	1.13E-05
8	1.13E-04	5.93E-06	9.94E-07.

[a]Dispersibility category 3 is described as loose chunks with an aerosol fraction of 1.00E-02 and a respirable fraction of 5.00E-02.
[b]R = rural, S = suburban, U = urban
[c]1 = interstate, 2 = U. S. highway, 3 = all other

Ci = curie
km = kilometer
LLW = low-level (radioactive) waste
m = meter

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considering a spectrum of transportation-related accidents. The spectrum of accidents is designed to encompass a range of possible accidents, including low-probability accidents with high consequences and high-probability accidents with low consequences ("fender benders"). Results for collective accident risk can be directly compared with results for routine collective risks because the former results incorporate probabilities of accident occurrences.

The RADTRAN 4 calculation of collective accident risk uses models that quantify the range of potential accident severities and responses of transported packages to accidents. The spectrum of accident severity is divided into a number of categories. Each category of severity is assigned a conditional probability of occurrence. The more severe the accident, the more remote the chance of such an accident. Release fractions, defined as the fraction of the material in a package that could be released in an accident, are assigned to each accident severity category on the basis of the physical and chemical form of the waste material. The models consider the transportation mode and the packaging type being considered.

For accidents involving release of radioactive material, RADTRAN 4 assumes the material is dispersed into the environment according to standard Gaussian diffusion models. For the risk assessment, default data for atmospheric dispersion representing an instantaneous ground-level release and a small-diameter source cloud were used. Calculation of the collective population dose after release and dispersal of radioactive material includes the following exposure pathways:

- external exposure to the passing radioactive cloud,
- external exposure to contaminated soil, and
- internal exposure from inhaling airborne contaminants.

A.1.2.2   Vehicle-Related (Nonradiological) Accident Risk Assessment

Vehicle-related accident risk refers to the potential for transportation-related accidents that directly result in injuries or fatalities not related to the shipment's cargo. This risk represents an estimate of the number of injuries or fatalities from mechanical causes. State-specific transportation injury and fatality rates were used in this assessment. Vehicle-related accident risks were calculated for each case by multiplying the total distance traveled in each state by the appropriate state rate for transportation-related injuries and fatalities. In all cases, vehicle-related accident risks were calculated using distances for round-trip shipment (DOE 1997a).

A.2. INPUT PARAMETERS AND ASSUMPTIONS

This section discusses principal input parameters and assumptions used in the transportation risk assessment.

A.2.1 WASTE INVENTORY AND CHARACTERIZATION DATA

An overview of waste characterization and packaging assumptions is presented in Sect. 4.2.2. Waste stream characteristics specific to RADTRAN 4 modeling are discussed here. RADTRAN 4 was developed for modeling radioactive material and includes a database for the most commonly transported radioisotopes. Five radioisotopes (^{237}Np, ^{228}Th, ^{230}Th, ^{232}Th, ^{234}U) identified in the LLW

inventory are not represented in the RADTRAN 4 database. Except for ^{232}Th, all these radionuclides are daughter products of radionuclides included in the RADTRAN 4 database and are represented by input parameters (for example, committed effective dose equivalent factor, photon energy) of their respective parent radionuclide. One radioisotope (^{152}Eu) identified in LLW inventory and included in the RADTRAN 4 database was not included in the transportation modeling. However, ^{152}Eu was only reported in one waste stream at a low activity, and it was not considered critical to the overall transportation risk assessment. Omission of these six radioisotopes from the transportation risk model is evaluated in the uncertainty analysis discussion in Sect. A.3.

A.2.2 SHIPMENT EXTERNAL DOSE RATES

The dose to populations during routine transportation is directly proportional to the assumed external dose rate from the shipment. The maximum external dose rate permitted for exclusive use shipments is 10 mrem/hour at a distance of 7 ft (for nonexclusive use, the distance is 3 ft). However, 1 mrem/hour was used in the calculations and is consistent with Table E-5 on page E-40 of the WM-PEIS (DOE 1997a). The actual shipment dose rate is a complex function of the composition and configuration of shielding and containment materials used in waste packaging, geometry of the loaded shipments, and characteristics of the waste material.

A.2.3 POPULATION DENSITY ZONES

Three population density zones were used for the population risk assessment: rural, suburban, and urban. Fractions of travel in each zone were determined by using the HIGHWAY and INTERLINE routing models. Route-specific population densities for rural, suburban, and urban zones are presented in Table A.3. These population densities are typical of rural, suburban, and urban environments. Occurrence of the three population density zones is based on an aggregation of the 12 population density zones provided in the HIGHWAY and INTERLINE model outputs (DOE 1997a).

A.2.4 ACCIDENT RATES

For calculating accident risks, vehicle accident injury and fatality rates were taken from data provided in *Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight* (Sariks and Kvitek 1994). For each transportation mode, accident rates are generically defined as the number of injuries or fatalities in a given year per unit of travel of that mode in the same year. Therefore, the rate is a fractional value—injury per fatality count is the numerator and total distance traveled is the denominator. Accident rates are derived from multiple-year averages that automatically consider such factors as heavy traffic and adverse weather conditions. For assessment purposes, the total number of expected injuries or fatalities is calculated by multiplying the total shipping distance for a specific case by the appropriate injury or fatality rate.

For truck transportation, rates are specifically for heavy combination trucks involved in interstate commerce. Heavy combination trucks are rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other and the tractor. Heavy combination trucks are typically used for shipping radioactive wastes. Truck accident rates are computed for each state on the basis of statistics compiled by the DOT Office of Motor Carriers for 1986 to 1988.

Table A.3. Route-specific population densities.

Source	Destination	Rural (people/mile²)	Suburban (people/mile²)	Urban (people/mile²)
Truck transportation				
WCS, TX	Clive, UT	10.4	1157.7	5545.8
ORR, TN	Mercury, NV	16.1	915.8	5763.7
	Clive, UT	15.9	881.1	5662.8
	WCS, TX	21.6	943.8	5247.6
	Hanford, WA	15.7	877	5659.5
	Aiken, SC	41.8	842.5	5556.2
	SRS, SC	43.5	851.4	5556.2
	Kingston, TN	35.6	232.5	0
Rail transportation				
ORR, TN	Caliente, NV	17.1	1022	5646.7
	Clive, UT	18.6	1020.9	5646.7
	WCS, TX	25.3	1028.6	5645.6
	Hanford, WA	17	963.8	5564.6
	SRS, SC	38.4	696.1	5742.4

NV = Nevada
ORR = Oak Ridge Reservation
SC = South Carolina
SRS = Savannah River Site
TN = Tennessee

TX = Texas
UT = Utah
WA = Washington
WCS = Waste Control Specialists

Rail accidents are computed and presented similarly to truck accident rates; however, the railcar is the unit of haulage for rail transport. State-specific rail accident injury and fatality rates are based on statistics compiled by the Federal Railroad Administration from 1985 to 1988 (DOE 1997a).

The accident assessment presented in this report used separate accident rates for travel in rural, suburban, and urban population density zones in each state. Therefore, total accident risk for a case depends on the total distance traveled in various population zones in each state and does not rely on national average statistics.

Note that accident rates used in this assessment were computed using all interstate shipments, regardless of cargo. Saricks and Kvitek (1994) emphasize that shippers and carriers of radioactive material generally have a higher-than-average awareness of transportation risk and prepare cargos

and drivers for such shipments accordingly. This preparation should have the twofold effect of reducing component and equipment failure and mitigating the contribution of human error to accident causation. These effects were not considered in the accident assessment.

A.2.5   ACCIDENT SEVERITY CATEGORIES

A method to characterize the potential severity of transportation-related accidents is described in NUREG-0170 (NRC 1977). The NRC method divides the spectrum of transportation accident severities into eight categories. This scheme is presented in Fig. A.1 for truck transportation and Fig. A.2 for rail transportation. Severity is described as a function of the magnitudes of mechanical forces (impact) and thermal forces (fire) to which a package may be subjected during an accident. Because all accidents can be described in these terms, severity is independent of the specific accident sequence. In other words, any sequence of events that results in an accident where a package is subjected to forces within a certain range of values is assigned to the accident severity category associated with that range. The scheme for accident severity is designed to consider all credible transportation-related accidents, including accidents with low probability but high consequences and those with high probability but low consequences (NRC 1977).

Each severity category represents a set of accident scenarios defined by a combination of mechanical and thermal forces. A conditional probability of occurrence is assigned to each category. Fractional occurrences for accidents by the accident severity category and the population density zone were calculated for this EA as in previous similar studies.

Category I accidents are the least severe but most frequent, whereas Category VIII accidents are very severe but very infrequent. To determine the expected frequency of an accident of given severity, the conditional probability in the category is multiplied by the baseline accident rate. Each population density zone has a distinct baseline accident rate and distribution of accident severities related to differences in average vehicular velocity, traffic density, and other factors, including location—rural, suburban, or urban.

A.2.6   PACKAGE RELEASE FRACTIONS

Radiological consequences are calculated by assigning package release fractions to each accident severity category. The release fraction is defined as the fraction of radioactive material in a package that could be released from that package during an accident of a certain severity. Release fractions consider all mechanisms necessary to create a release of radioactive material from a damaged package to the environment. Release fractions vary according to package type and physical form of the waste (Neuhauser and Kanipe 1993).

A.2.7   ATMOSPHERIC CONDITIONS

Radioactive material released to the atmosphere is transported by wind. The amount of dispersion or dilution of radioactive material in the air depends on meteorologic conditions at the time of the accident. Because predicting the specific location of an off-site transportation-related accident is impossible, generic atmospheric conditions were selected for the accident risk and consequence assessments.

Neutral weather conditions were assumed for the accident risk assessment; these conditions were represented by Pasquill stability Class D with a windspeed of 9 miles/hour. Because neutral meteorologic conditions constitute the most frequently occurring atmospheric stability condition in the United States, these conditions are most likely to be present if an accident involves a waste shipment. Observations at National Weather Service surface meteorologic stations from more than 300 U.S. locations indicate that on a yearly average, neutral conditions (represented by Pasquill

A-11
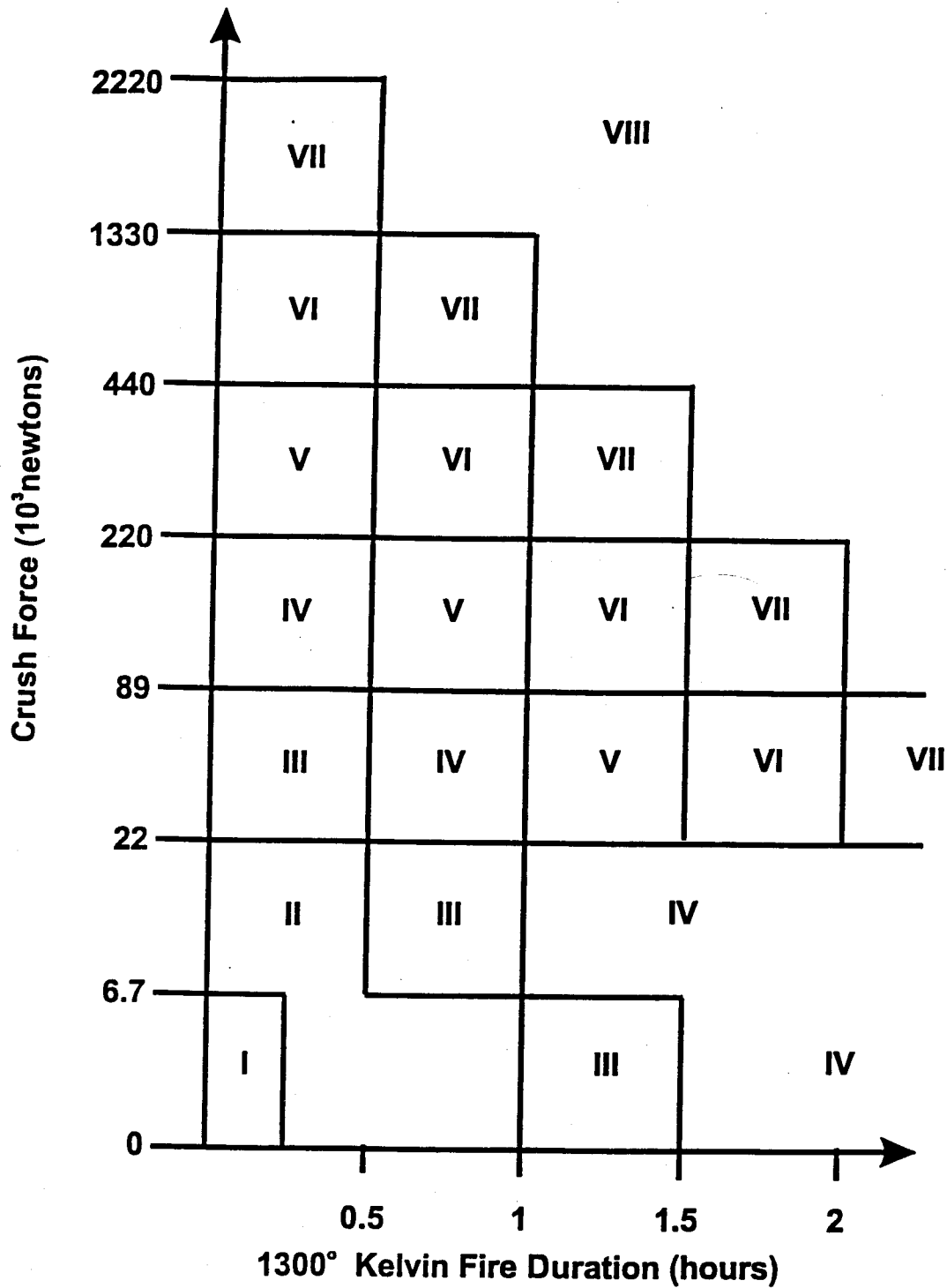
Reference: NRC (1977)
CMA2604

Fig. A.1
Scheme for NUREG-0170 Classification by Accident Severity Category for Truck Accidents

DOCUMENT ID: 35H830 00161-40 / EA	DRAWING ID: 00-18705.CDR	DRAWING DATE: April 5, 2000 SB

Fig. A.2

Scheme for NUREG-0170 Classification by Accident Severity Category for Rail Accidents
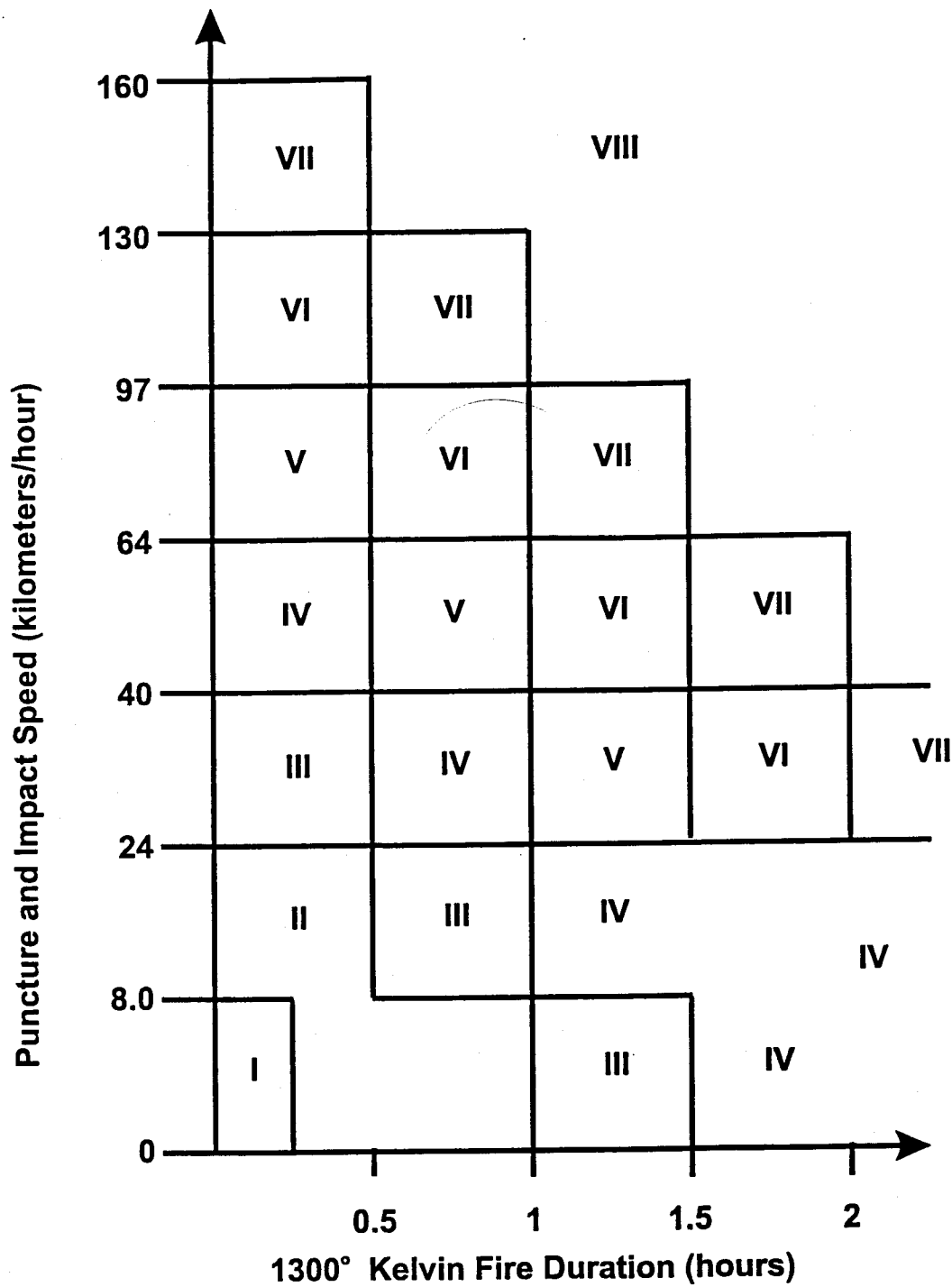
Reference: NRC (1997)
CMA2604

DOCUMENT ID: 35H830 00161-40 / EA	DRAWING ID: 00-18706.CDR	DRAWING DATE: April 5, 2000 SB

Classes C and D) occur about 50 percent of the time, while stable conditions occur about 33 percent of the time (Pasquill Classes E and F), and unstable conditions (Pasquill Classes A and B) occur about 17 percent of the time (DOE 1997a).

A.2.8 HEALTH RISK CONVERSION FACTORS

Radiation doses to the population and truck crews were converted to estimates of latent cancer fatalities (LCFs) using the upper limit risk coefficient suggested by the National Academy of Sciences (NAS 1990). The NAS report, referred to as the BEIR V report, gives statistics on the number of cancer deaths expected to occur from a continuous exposure of 1 rem/year from age 18 until age 65. This value results in a risk factor of 4.0×10^{-4} LCFs/person-rem that is most applicable to occupational exposures. The BEIR V report also considers the number of cancer deaths expected to occur from a continuous lifetime exposure of 0.1 rem/year, which results in a risk factor of 5.0×10^{-4} LCFs/person-rem that is most applicable to exposures of the general public. Both these risk factors were used in this study depending on whether the exposure was occupational or received by the general population.

A.3. UNCERTAINTY ANALYSIS

Evaluation of potential risks associated with transportation of LLW is an analytical process subject to uncertainty. Uncertainties associated with the computational models are minimized by using computer codes that have been extensively reviewed. However, because numerous uncertainties are recognized but are difficult to quantify, assumptions are made at each step of the risk assessment process that are intended to produce conservative results. Because parameters and assumptions are applied equally to all cases, this model bias is not expected to affect the meaningfulness of relative comparisons of risk; however, results may not represent risks in an absolute sense. The following sections discuss specific areas of uncertainty and their potential impact on the projected risks.

Models used to calculate radiation doses from transportation activities introduce additional uncertainty into the risk assessment process. Accuracy of the calculated results is closely related to limitations of the computational models and to uncertainties in each of the input parameters that the model requires (Neuhauser and Kanipe 1993).

Conceptual routes have been determined to various potential waste disposal (and/or treatment) locations. Routes have been determined consistent with current federal guidelines, regulations, and practices but may not be the actual routes used in the future. Differences in routes may include distance and total populations affected. Uncertainty associated with selection of routes is not likely to result in a substantial over- or underestimation of potential risks. Regulations for routing LLW shipments generally favor travel through less populated areas; therefore, an increase in distance will not greatly increase the potential risk to the public. Average population densities have been applied for rural, suburban, and urban areas for each conceptual route considered. Use of average values will tend to overestimate potential risks for some transportation segments and underestimate potential risk for others. Use of average values should therefore have a neutral effect on the potential risk estimates.

Radionuclides and their respective concentrations in LLW inventory were derived from data collected to characterize the waste streams. The identity of the radionuclides and their average activity are known. However, as previously stated, some radionuclides were not included in the assessment. These radionuclides represent a small percentage of the total radionuclide content in the LLW inventory or are accounted for in input parameters for their parent radionuclide. Therefore,

omission of these radionuclides from the assessment is not likely to result in an underestimation of potential risks.

A.4. RESULTS OF RISK ASSESSMENT

This section presents results of the risk assessment for transportation of LLW. For each case, risks related to the transportation of radioactive waste were evaluated for three consequences: (1) excess cancer risk from exposure to gamma radiation during incident free transportation, (2) excess cancer risk resulting from exposure to contaminants released in an accident, and (3) injury or fatality as a result of physical trauma from vehicle collisions. The total number of shipments and mileage for loaded shipments for each LLW case are discussed in Sects. 4.2.1 and 3.2.

A.4.1 TRANSPORTATION RISK SUMMARY

Results of the transportation risk assessment are summarized in Table A.4 for shipments of heterogeneous waste; Table A.5 for shipments of scrap metal; and Table A.6 for shipments of remote-handled waste. Results are presented on a per-shipment basis and for the total number of shipments.

A.4.2 VEHICLE-RELATED RISK SUMMARY

The projected number of nonradiological injuries and fatalities from trauma resulting from vehicle collisions are summarized in Tables A.7 and A.8 for truck and rail transport, respectively.

Table A.4. Transportation risk assessment results for shipments of heterogeneous LLW

Summary of dose to crew, general population, and single individual from one shipment of heterogeneous LLW by truck in 80 drums from the Oak Ridge area

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Aiken, SC	5.87E-03	8.22E-06	2.35E-06	8.40E-03	1.43E-05	4.20E-06	1.40E-05	2.38E-08	7.00E-09	9.84E-08	1.67E-10	4.92E-11
Clive, UT	2.21E-02	3.09E-05	8.84E-06	2.41E-02	4.10E-05	1.21E-05	2.58E-05	4.39E-08	1.29E-08	9.84E-08	1.67E-10	4.92E-11
Richland, WA	2.73E-02	3.82E-05	1.09E-05	2.69E-02	4.57E-05	1.35E-05	2.74E-05	4.66E-08	1.37E-08	9.84E-08	1.67E-10	4.92E-11
Kingston, TN	1.40E-04	1.96E-07	5.60E-08	1.38E-04	2.35E-07	6.90E-08	8.26E-08	1.40E-10	4.13E-11	9.84E-08	1.67E-10	4.92E-11
Mercury, NV	2.25E-02	3.15E-05	9.00E-06	2.53E-02	4.30E-05	1.27E-05	2.80E-05	4.76E-08	1.40E-08	9.84E-08	1.67E-10	4.92E-11
Aiken, SC	5.65E-03	7.91E-06	2.26E-06	8.25E-03	1.40E-05	4.13E-06	1.39E-05	2.36E-08	6.95E-09	9.84E-08	1.67E-10	4.92E-11
Andrews, TX	1.50E-02	2.10E-05	6.00E-06	1.80E-02	3.06E-05	9.00E-06	2.44E-05	4.15E-08	1.22E-08	9.84E-08	1.67E-10	4.92E-11

Summary of dose to crew, general population, and single individual from one shipment of heterogeneous LLW by rail in 300 drums from the Oak Ridge area

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Caliente, NV	5.38E-03	7.53E-06	2.15E-06	2.18E-03	3.71E-06	1.90E-06	9.07E-05	1.54E-07	4.54E-08	9.84E-08	1.67E-10	4.92E-11
Clive, UT	4.81E-03	6.73E-06	1.92E-06	2.10E-03	3.57E-06	1.05E-06	8.96E-05	1.52E-07	4.48E-08	9.84E-08	1.67E-10	4.92E-11
Richland, WA	6.12E-03	8.57E-06	2.45E-06	2.29E-03	3.89E-06	1.15E-06	8.92E-05	1.52E-07	4.46E-08	9.84E-08	1.67E-10	4.92E-11
Aiken, SC	1.06E-03	1.48E-06	4.24E-07	1.24E-03	2.11E-06	6.20E-07	4.48E-05	7.62E-08	2.24E-08	9.84E-08	1.67E-10	4.92E-11
Andrews, TX	3.21E-03	4.49E-06	1.28E-06	2.99E-03	5.08E-06	1.50E-06	1.11E-04	1.89E-07	5.55E-08	9.84E-08	1.67E-10	4.92E-11

Table A.4. (continued)

Summary of dose to crew, general population, and single individual from all shipments of heterogeneous LLW by truck in 80 drums from the Oak Ridge area for the 20-year waste generation life cycle

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Aiken, SC	4.52E+01	6.33E-02	1.81E-02	6.47E+01	1.10E-01	3.24E-02	1.08E-01	1.83E-04	5.40E-05	7.58E-04	1.29E-06	3.79E-07
Clive, UT	1.70E+02	2.38E-01	6.81E-02	1.86E+02	3.16E-01	9.29E-02	1.99E-01	3.38E-04	9.94E-05	7.58E-04	1.29E-06	3.79E-07
Richland, WA	2.10E+02	2.95E-01	8.42E-02	2.07E+02	3.52E-01	1.04E-01	2.11E-01	3.59E-04	1.06E-04	7.58E-04	1.29E-06	3.79E-07
Kingston, TN	1.08E+00	1.51E-03	4.32E-04	1.06E+00	1.81E-03	5.32E-04	6.37E-04	1.08E-06	3.18E-07	7.58E-04	1.29E-06	3.79E-07
Mercury, NV	1.73E+02	2.43E-01	6.94E-02	1.95E+02	3.32E-01	9.75E-02	2.16E-01	3.67E-04	1.08E-04	7.58E-04	1.29E-06	3.79E-07
Aiken, SC	4.36E+01	6.10E-02	1.74E-02	6.36E+01	1.08E-01	3.18E-02	1.07E-01	1.82E-04	5.36E-05	7.58E-04	1.29E-06	3.79E-07
Andrews, TX	1.16E+02	1.62E-01	4.62E-02	1.39E+02	2.36E-01	6.94E-02	1.88E-01	3.20E-04	9.40E-05	7.58E-04	1.29E-06	3.79E-07

Summary of dose to crew, general population, and single individual from all shipments of heterogeneous LLW by truck in 80 drums from the Oak Ridge area for the 20-year waste generation life cycle

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Caliente, NV	1.10E+01	1.53E-02	4.38E-03	4.44E+00	7.55E-03	2.22E-03	1.85E-01	3.14E-04	9.24E-05	2.00E-04	3.41E-07	1.00E-07
Clive, UT	9.80E+00	1.37E-02	3.92E-03	4.28E+00	7.27E-03	2.14E-03	1.83E-01	3.10E-04	9.13E-05	2.00E-04	3.41E-07	1.00E-07
Richland, WA	1.25E+01	1.75E-02	4.99E-03	4.66E+00	7.93E-03	2.33E-03	1.82E-01	3.09E-04	9.09E-05	2.00E-04	3.41E-07	1.00E-07
Aiken, SC	2.16E+00	3.02E-03	8.64E-04	2.53E+00	4.29E-03	1.26E-03	9.13E-02	1.55E-04	4.56E-05	2.00E-04	3.41E-07	1.00E-07
Andrews, TX	6.54E+00	9.15E-03	2.62E-03	6.09E+00	1.04E-02	3.05E-03	2.26E-01	3.84E-04	1.13E-04	2.00E-04	3.41E-07	1.00E-07

LLW = low-level (radioactive) waste
NV = Nevada
rem = roentgen equivalent man
SC = South Carolina

TN = Tennessee
TX = Texas
UT = Utah
WA = Washington

Table A.5. Transportation risk assessment results for shipments of scrap metal LLW

Summary of dose to crew, general population, and single individual from one shipment of scrap metal LLW by truck in sealand container from the Oak Ridge area

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Aiken, SC	2.92E-03	4.09E-06	1.17E-06	4.20E-03	7.14E-06	2.10E-06	2.08E-10	3.54E-13	1.04E-13	4.90E-08	8.33E-11	2.45E-11
Clive, UT	1.10E-02	1.54E-05	4.40E-06	1.20E-02	2.04E-05	6.00E-06	3.82E-10	6.49E-13	1.91E-13	4.90E-08	8.33E-11	2.45E-11
Richland, WA	1.36E-02	1.90E-05	5.44E-06	1.34E-02	2.28E-05	6.70E-06	4.06E-10	6.90E-13	2.03E-13	4.90E-08	8.33E-11	2.45E-11
Kingston, TN	6.95E-05	9.73E-08	2.78E-08	6.85E-05	1.16E-07	3.43E-08	1.22E-12	2.07E-15	6.10E-16	4.90E-08	8.33E-11	2.45E-11
Mercury, NV	1.12E-02	1.57E-05	4.48E-06	1.26E-02	2.14E-05	6.30E-06	4.14E-10	7.04E-13	2.07E-13	4.90E-08	8.33E-11	2.45E-11
Aiken, SC	2.81E-03	3.93E-06	1.12E-06	4.10E-03	6.97E-06	2.05E-06	2.06E-10	3.50E-13	1.03E-13	4.90E-08	8.33E-11	2.45E-11
Andrews, TX	7.46E-03	1.04E-05	2.98E-06	8.94E-03	1.52E-05	4.47E-06	3.61E-10	6.14E-13	1.81E-13	4.90E-08	8.33E-11	2.45E-11

Summary of dose to crew, general population, and single individual from one shipment of scrap metal LLW by rail in sealand container from the Oak Ridge area

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Caliente, NV	3.80E-03	5.32E-06	1.52E-06	1.08E-03	1.84E-06	5.40E-07	3.57E-10	6.07E-13	1.79E-13	4.90E-08	8.33E-11	2.45E-11
Clive, UT	3.39E-03	4.75E-06	1.36E-06	1.05E-03	1.79E-06	5.25E-07	3.53E-10	6.00E-13	1.77E-13	4.90E-08	8.33E-11	2.45E-11
Richland, WA	4.32E-03	6.05E-06	1.73E-06	1.14E-03	1.94E-07	5.70E-07	3.51E-10	5.97E-13	1.76E-13	4.90E-08	8.33E-11	2.45E-11
Aiken, SC	7.45E-04	1.04E-06	2.98E-07	6.25E-04	1.06E-06	3.13E-07	1.77E-10	3.01E-13	8.85E-14	4.90E-08	8.33E-11	2.45E-11
Andrews, TX	2.27E-03	3.18E-06	9.08E-07	1.49E-03	2.53E-06	7.45E-07	4.38E-10	7.45E-13	2.19E-13	4.90E-08	8.33E-11	2.45E-11

Table A.5 (continued)

Summary of dose to crew, general population, and single individual from all shipments of scrap metal LLW by truck in sealand container from the Oak Ridge area for the 20-year waste generation life cycle

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Aiken, SC	6.92E+00	9.69E-03	2.77E-03	9.95E+00	1.69E-02	4.98E-03	4.93E-07	8.38E-10	2.46E-10	1.16E-04	1.97E-07	5.81E-08
Clive, UT	2.61E+01	3.65E-02	1.04E-02	2.84E+01	4.83E-02	1.42E-02	9.05E-07	1.54E-09	4.53E-10	1.16E-04	1.97E-07	5.81E-08
Richland, WA	3.22E+01	4.51E-02	1.29E-02	3.18E+01	5.40E-02	1.59E-02	9.62E-07	1.64E-09	4.81E-10	1.16E-04	1.97E-07	5.81E-08
Kingston, TN	1.65E-01	2.31E-04	6.59E-05	1.62E-01	2.76E-04	8.12E-05	2.89E-09	4.92E-12	1.45E-12	1.16E-04	1.97E-07	5.81E-08
Mercury, NV	2.65E+01	3.72E-02	1.06E-02	2.99E+01	5.08E-02	1.49E-02	9.81E-07	1.67E-09	4.91E-10	1.16E-04	1.97E-07	5.81E-08
Aiken, SC	6.66E+00	9.32E-03	2.66E-03	9.72E+00	1.65E-02	4.86E-03	4.88E-07	8.30E-10	2.44E-10	1.16E-04	1.97E-07	5.81E-08
Andrews, TX	1.77E+01	2.48E-02	7.07E-03	2.12E+01	3.60E-02	1.06E-02	8.56E-07	1.45E-09	4.28E-10	1.16E-04	1.97E-07	5.81E-08

Summary of dose to crew, general population, and single individual from one shipment of scrap metal LLW by rail in sealand container from the Oak Ridge area for the 20-year waste generation life cycle

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Caliente, NV	9.01E+00	1.26E-02	3.60E-03	2.56E+00	4.35E-03	1.28E-03	8.46E-07	1.44E-09	4.23E-10	1.16E-04	1.97E-07	5.81E-08
Clive, UT	8.03E+00	1.12E-02	3.21E-03	2.49E+00	4.23E-03	1.24E-03	8.37E-07	1.42E-09	4.18E-10	1.16E-04	1.97E-07	5.81E-08
Richland, WA	1.02E+01	1.43E-02	4.10E-03	2.70E+00	4.59E-03	1.35E-03	8.32E-07	1.41E-09	4.16E-10	1.16E-04	1.97E-07	5.81E-08
Aiken, SC	1.77E+00	2.47E-03	7.06E-04	1.48E+00	2.52E-03	7.41E-04	4.19E-07	7.13E-10	2.10E-10	1.16E-04	1.97E-07	5.81E-08
Andrews, TX	5.38E+00	7.53E-03	2.15E-03	3.53E+00	6.00E-03	1.77E-03	1.04E-06	1.76E-09	5.19E-10	1.16E-04	1.97E-07	5.81E-08

LLW = low-level (radioactive) waste
NV = Nevada
rem = roentgen equivalent man
SC = South Carolina

TN = Tennessee
TX = Texas
UT = Utah
WA = Washington

Table A.6. Transportation risk assessment results for shipments for Type B LLW

Summary of dose to crew, general population, and single individual from one shipment by truck of Type B LLW from the Oak Ridge area

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Richland, WA	1.36E-01	1.90E-04	5.44E-05	3.30E-02	5.61E-05	1.65E-05	1.22E-07	2.07E-10	6.10E-11	1.22E-07	2.07E-10	6.10E-11
Mercury, NV	1.12E-01	1.57E-04	4.48E-05	3.10E-02	5.27E-05	1.55E-05	1.22E-07	2.07E-10	6.10E-11	1.22E-07	2.07E-10	6.10E-11
Aiken, SC	2.81E-02	3.93E-05	1.12E-05	1.02E-02	1.73E-05	5.10E-06	1.22E-07	2.07E-10	6.10E-11	1.22E-07	2.07E-10	6.10E-11

Summary of dose to crew, general population, and single individual from all shipments by truck of Type B LLW from the Oak Ridge area for the 20-year waste generation life cycle

Destination	Crew dose (person-rem)	Induced cancers	Cancer fatalities	Population dose (person-rem)	Induced cancers	Cancer fatalities	Population exposure in accident (person-rem)	Induced cancers	Cancer fatalities	Maximum individual (rem)	Induced cancers	Cancer fatalities
Richland, WA	5.17E+00	7.24E-03	2.07E-03	1.25E+00	2.13E-03	6.27E-04	4.64E-06	7.88E-09	2.32E-09	4.64E-06	7.88E-09	2.32E-09
Mercury, NV	4.26E+00	5.96E-03	1.70E-03	1.18E+00	2.00E-03	5.89E-04	4.64E-06	7.88E-09	2.32E-09	4.64E-06	7.88E-09	2.32E-09
Aiken, SC	1.07E+00	1.49E-03	4.27E-04	3.88E-01	6.59E-04	1.94E-04	4.64E-06	7.88E-09	2.32E-09	4.64E-06	7.88E-09	2.32E-09

LLW = low-level (radioactive) waste
NV = Nevada
rem = roentgen equivalent man

SC = South Carolina
WA = Washington

Table A.7. Projected number of nonradiological injuries and fatalities resulting from collisions when shipping LLW by truck from the Oak Ridge area

	Routing information and results by state for shipment of scrap and heterogeneous waste only to Clive, UT								
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	210.0	337.9	675.8	2.410E-07	2.280E-08	2.E-04	2.E-05	—	—
KY	95.0	152.9	305.7	1.940E-07	1.750E-08	6.E-05	5.E-06	—	—
IL	178.0	286.4	572.8	3.200E-07	2.380E-08	2.E-04	1.E-05	—	—
MO	375.0	603.4	1206.8	2.590E-07	1.990E-08	3.E-04	2.E-05	—	—
IA	100.0	160.9	321.8	1.760E-07	1.260E-08	6.E-05	4.E-06	—	—
NE	459.0	738.5	1477.1	1.500E-07	1.430E-08	2.E-04	2.E-05	—	—
WY	402.0	646.8	1293.6	2.740E-07	2.010E-08	4.E-04	3.E-05	—	—
UT[b] (Clive)	161.0	259.0	518.1	2.280E-07	2.030E-08	1.E-04	1.E-05	—	—
Totals	1980.0	3185.8	6371.6			1.E-03	1.E-04	15	1

	Routing information and results by state for shipment of scrap and heterogeneous waste only to Andrews, TX								
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	375.0	603.4	1206.8	2.410E-07	2.280E-08	3.E-04	3.E-05	—	—
AR	274.0	440.9	881.7	2.200E-07	2.780E-08	2.E-04	2.E-05	—	—
TX (Andrews)	607.0	976.7	1953.3	1.830E-07	1.950E-08	4.E-04	4.E-05	—	—
Totals	1256.0	2020.9	4041.8			8.E-04	9.E-05	8	1

Table A.7. (continued)

Routing information and results by state for shipment of scrap, heterogeneous, and Type B wastes to Richland, WA									
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	210.0	337.9	675.8	2.410E-07	2.280E-08	2.E-04	2.E-05	—	—
KY	95.0	152.9	305.7	1.940E-07	1.750E-08	6.E-05	5.E-06	—	—
IL	178.0	286.4	572.8	3.200E-07	2.380E-08	2.E-04	1.E-05	—	—
MO	375.0	603.4	1206.8	2.590E-07	1.990E-08	3.E-04	2.E-05	—	—
IA	100.0	160.9	321.8	1.760E-07	1.260E-08	6.E-05	4.E-06	—	—
NE	459.0	738.5	1477.1	1.500E-07	1.430E-08	2.E-04	2.E-05	—	—
WY	402.0	646.8	1293.6	2.740E-07	2.010E-08	4.E-04	3.E-05	—	—
UT[b]	148.0	238.1	476.3	2.280E-07	2.030E-08	1.E-04	1.E-05	—	—
ID	274.0	440.9	881.7	1.990E-07	1.780E-08	2.E-04	2.E-05	—	—
OR	209.0	336.3	672.6	2.020E-07	1.330E-08	1.E-04	9.E-06	—	—
WA (Richland)	46.0	74.0	148.0	1.850E-07	1.170E-08	3.E-05	2.E-06	—	—
Totals	2496.0	4016.1	8032.1	—	—	2.E-03	1.E-04	18	1

Routing information and results by state for shipment of scrap and heterogeneous waste only to commercial facilities near Aiken, SC									
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	94.0	151.2	302.5	2.410E-07	2.280E-08	7.E-05	7.E-06	—	—
GA	255.0	410.3	820.6	2.260E-07	1.960E-08	2.E-04	2.E-05	—	—
SC (Aiken)	65.0	104.6	209.2	2.260E-07	2.610E-08	5.E-05	5.E-06	—	—
Totals	414.0	666.1	1332.3	—	—	3.E-04	3.E-05	3	0

Table A.7 (continued)

	Routing information and results by state for shipment of scrap and heterogeneous, and Type B wastes to Aiken, SC								
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	94.0	151.2	302.5	2.410E-07	2.280E-08	7.E-05	7.E-06	—	—
GA	255.0	410.3	820.6	2.260E-07	1.960E-08	2.E-04	2.E-05	—	—
SC (Aiken)	45.0	72.4	144.8	2.260E-07	2.610E-08	5.E-05	5.E-06	—	—
Totals	394.0	633.9	1267.9	—	—	3.E-04	3.E-05	3	0

	Routing information and results by state for shipment of scrap, heterogeneous, and Type B wastes to Mercury, NV								
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	375.0	603.4	1206.8	2.410E-07	2.280E-08	3.E-04	3.E-05	—	—
AR	284.0	457.0	913.9	2.200E-07	2.780E-08	2.E-04	3.E-05	—	—
OK	334.0	537.4	1074.8	1.740E-07	2.180E-08	2.E-04	2.E-05	—	—
TX	177.0	284.8	569.6	1.830E-07	1.950E-08	1.E-04	1.E-05	—	—
NM	373.0	600.2	1200.3	2.250E-07	2.320E-08	3.E-04	3.E-05	—	—
AZ	380.0	611.4	1222.8	1.820E-07	2.330E-08	2.E-04	3.E-05	—	—
NV (Mercury)	98.0	157.7	315.4	1.930E-07	1.790E-08	6.E-05	6.E-06	—	—
Totals	2021.0	3251.8	6503.6	—	—	1.E-03	1.E-04	14	2

[a]Injury and fatality rate data from Table A.4, Saricks, C. and T. Kvitek. 1994. *Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight.* ANL/ESD/TM-68. Argonne National Laboratory, Argonne, IL.
[b]Values for UT were not reported in Table A.5, Saricks and Kvitek 1994; therefore, national average rates were used.

AR = Arkansas	IL = Illinois
AZ = Arizona	IN = Indiana
CO = Colorado	km = kilometer
GA = Georgia	KY = Kentucky
IA = Iowa	MO = Missouri
ID = Idaho	

MS = Mississippi
NE = Nebraska
NM = New Mexico
NV = Nevada
OK = Oklahoma

OR = Oregon
TN = Tennessee
TX = Texas
UT = Utah
WY = Wyoming

Table A.8. Projected number of nonradiological injuries and fatalities resulting from collisions when Shipping heterogeneous and scrap metal LLW by rail from the Oak Ridge area

	Routing information and results by state for shipment of heterogeneous and scrap metal waste to Clive, UT								
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	76.8	123.6	247.1	7.830E-08	6.500E-10	2.E-05	2.E-07	—	—
KY	203.0	326.6	653.3	7.830E-08	6.500E-10	5.E-05	4.E-07	—	—
IN	123.0	197.9	395.8	7.830E-08	6.500E-10	3.E-05	3.E-07		
IL	157.1	252.8	505.5	7.830E-08	6.500E-10	4.E-05	3.E-07	—	—
MO	273.7	440.4	880.8	7.830E-08	6.500E-10	7.E-05	6.E-07	—	—
KS	172.8	278.0	556.1	7.830E-08	6.500E-10	4.E-05	4.E-07	—	—
NE	403.5	649.2	1298.5	7.830E-08	6.500E-10	1.E-04	8.E-07	—	—
CO	10.0	16.1	32.2	7.830E-08	6.500E-10	3.E-06	2.E-08		
WY	438.6	705.7	1411.4	7.830E-08	6.500E-10	1.E-04	9.E-07	—	—
UT (Clive)	183.1	294.6	589.2	7.830E-08	6.500E-10	5.E-05	4.E-07	—	—
Totals	2041.6	3284.9	6569.9	—	—	5.E-04	4.E-06	2	0

	Routing information and results by state for shipment of scrap, heterogeneous, and Type B wastes to Mercury, NV								
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	204.1	328.4	656.8	7.830E-08	6.500E-10	5.E-05	4.E-07	—	—
AL	160.2	257.8	515.5	7.830E-08	6.500E-10	4.E-05	3.E-07	—	—
MS	32.0	51.5	103.0	7.830E-08	6.500E-10	8.E-06	7.E-08	—	—
AR	285.2	458.9	917.8	7.830E-08	6.500E-10	7.E-05	6.E-07	—	—
TX (Andrews)	646.4	1040.1	2080.1	7.830E-08	6.500E-10	2.E-04	1.E-06	—	—
Totals	1327.9	2136.6	4273.2	—	—	3.E-04	3.E-06	1	0

Table A.8 (continued)

Routing information and results by state for shipment of heterogeneous and scrap metal waste to Richland, WA									
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	76.8	123.6	247.1	7.830E-08	6.500E-10	2.E-05	2.E-07	--	--
KY	203.0	326.6	653.3	7.830E-08	6.500E-10	5.E-05	4.E-07	--	--
IN	123.0	197.9	395.8	7.830E-08	6.500E-10	3.E-05	3.E-07		
IL	157.1	252.8	505.5	7.830E-08	6.500E-10	4.E-05	3.E-07	--	--
MO	273.7	440.4	880.8	7.830E-08	6.500E-10	7.E-05	6.E-07	--	--
KS	172.8	278.0	556.1	7.830E-08	6.500E-10	4.E-05	4.E-07	--	--
NE	403.5	649.2	1298.5	7.830E-08	6.500E-10	1.E-04	8.E-07	--	--
CO	10.0	16.1	32.2	7.830E-08	6.500E-10	3.E-06	2.E-08		
WY	461.0	741.7	1483.5	7.830E-08	6.500E-10	1.E-04	1.E-06	--	--
ID	438.2	705.1	1410.1	7.830E-08	6.500E-10	1.E-04	9.E-07		
OR	232.6	374.3	748.5	7.830E-08	6.500E-10	6.E-05	5.E-07		
WA (Richland)	52.9	85.1	170.2	7.830E-08	6.500E-10	1.E-05	1.E-07		
Totals	2604.6	4190.8	8381.6	--	--	7.E-04	5.E-06	3	0

Routing information and results by state for shipment of scrap, heterogeneous, and Type B wastes to Mercury, NV									
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	107.1	172.3	344.6	7.830E-08	6.500E-10	3.E-05	2.E-07	--	--
GA	299.6	482.1	964.1	7.830E-08	6.500E-10	8.E-05	6.E-07	--	--
SC (Aiken)	42.5	68.4	136.8	7.830E-08	6.500E-10	1.E-05	9.E-08	--	--
Totals	449.2	722.8	1445.5	--	--	1.E-04	9.E-07	--	--

Table A.8 (continued)

|	Routing information and results by state for shipment of heterogeneous and scrap metal waste to Caliente, NV								
State	Miles traveled (one way)	Kilometers traveled (one way)	Kilometers traveled (round trip)	Injuries per km[a]	Fatalities per km[a]	Total injuries per shipment	Total fatalities per shipment	Total injuries all shipments	Total fatalities all shipments
TN	76.8	123.6	247.1	7.830E-08	6.500E-10	2.E-05	2.E-07	—	—
KY	203.0	326.6	653.3	7.830E-08	6.500E-10	5.E-05	4.E-07	—	—
IN	123.0	197.9	395.8	7.830E-08	6.500E-10	3.E-05	3.E-07		
IL	157.1	252.8	505.5	7.830E-08	6.500E-10	4.E-05	3.E-07	—	—
MO	173.7	279.5	559.0	7.830E-08	6.500E-10	4.E-05	4.E-07	—	—
KS	172.8	278.0	556.1	7.830E-08	6.500E-10	4.E-05	4.E-07	—	—
NE	403.5	649.2	1298.5	7.830E-08	6.500E-10	1.E-04	8.E-07	—	—
CO	10.0	16.1	32.2	7.830E-08	6.500E-10	3.E-06	2.E-08		
WY	438.6	705.7	1411.4	7.830E-08	6.500E-10	1.E-04	9.E-07	—	—
UT	389.8	627.2	1254.4	7.830E-08	6.500E-10	1.E-04	8.E-07	—	—
NV (Caliente)	41.3	66.5	132.9	7.830E-08	6.500E-10	1.E-05	9.E-08	—	—
Totals	2189.6	3523.1	7046.1	—	—	6.E-04	5.E-06	2	0

[a]Injury and fatality rate data from Saricks, C. and T. Kvitek. 1994. *Longitudinal Review of State-Level Accident Statistics for Carriers of Interstate Freight.* ANL/ESD/TM-68. Argonne National Laboratory, Argonne, IL; only national average values were reported.

AR = Arkansas
CO = Colorado
GA = Georgia
IA = Iowa
ID = Idaho
IL = Illinois
IN = Indiana
km = kilometer
KY – Kentucky
MO = Missouri

MS = Mississippi
NE = Nebraska
NM = New Mexico
NV = Nevada
OK = Oklahoma
OR = Oregon
TN = Tennessee
TX = Texas
UT = Utah
WY = Wyoming

APPENDIX B

RECORD OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL ASSESSMENT AND DOE'S RESPONSES
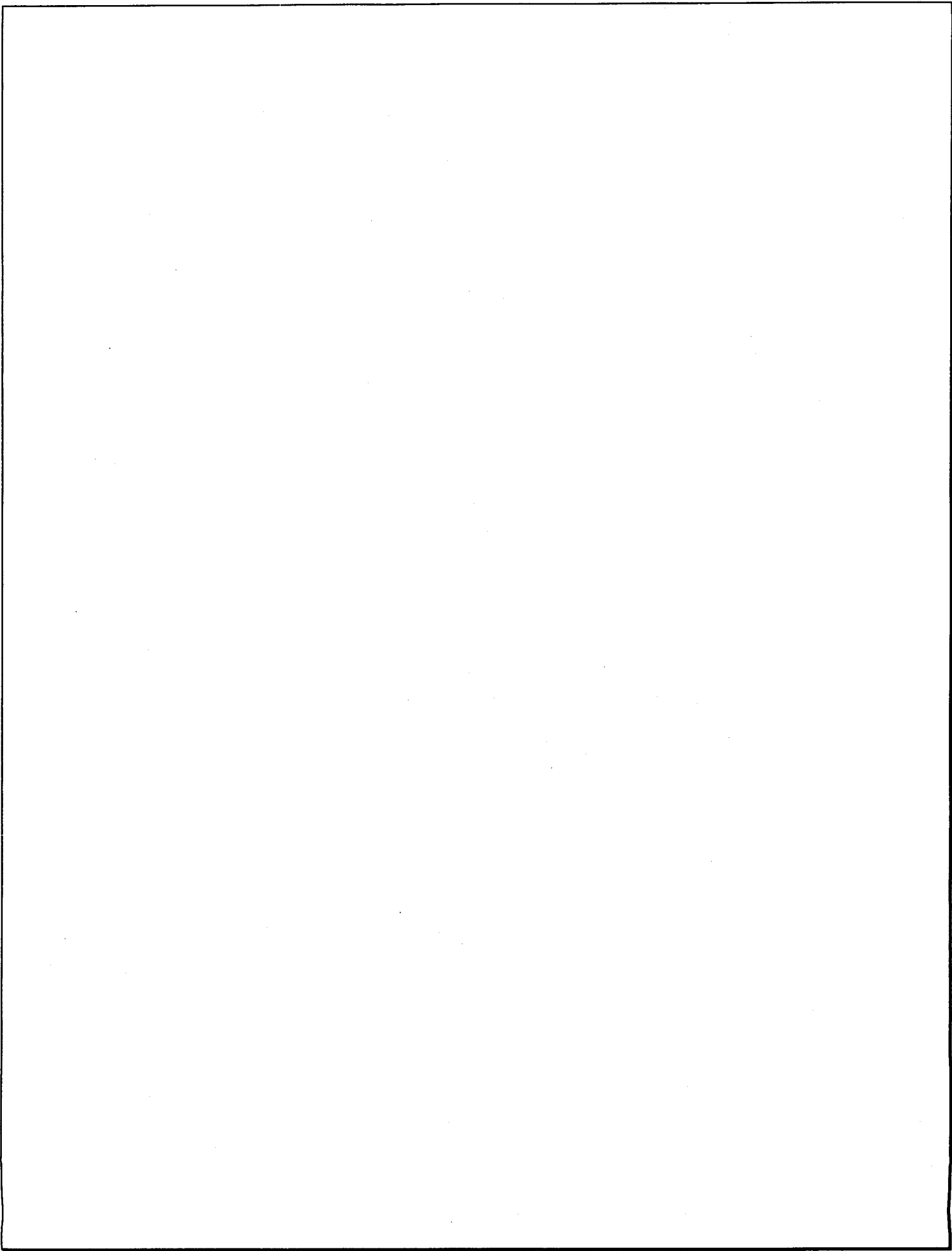
LLW Environmental Assessment Comment Record

Title of Document: Environmental Assessment for the Transportation of Low-Level Radioactive Waste from the Oak Ridge Reservation to Off-Site Treatment or Disposal Facilities

Document number or other identifier: DOE/EA-1315

Name of Commentor:	Norman A. Mullvenon, Susan Garwarecki
Organization of Commentor:	Oak Ridge Reservation Local Oversight Committee

Name of Commentor:	A. J. Kuhaida, Jr.
Organization of Commentor:	City of Oak Ridge, Environmental Quality Advisory Board

General comments

Comment No.	Page/ Reference	Comment	Response
1	General	The EA assesses the transportation of radioactive scrap metal currently included in the ORR inventory. With the moratorium on recycling of surface-contaminated scrap metal, a substantially larger amount of metal must be handled as waste; it would be useful to include an assessment of the impacts of this larger volume of scrap metal. This additional analysis would help in understanding some of the implications of the moratorium on metal recycling; and it would provide NEPA coverage for the expanded transportation program that likely will be needed now that recycling is curtailed.	As surmised in this comment, scrap metal that would be recycled, in particular from the BNFL project, was not included in the LLW analyses of this EA. However, it would not be appropriate to assume that the LLW transportation program covered in this EA will be expanded to include these materials.

It is not at all certain that surface-contaminated scrap metal, otherwise eligible for recycling , would be shipped off-site for disposal. Decisions relate to the disposition of this type of scrap metal have not yet been made. |
| 1* (continued) | | | The BNFL D&D project referred to in the comment was authorized under CERCLA. This EA addresses legacy and operational waste. It does not address waste generated by CERCLA actions. (Scrap metal characterized as LLW could also be eligible for disposal at the Environmental Management Waste Management facility currently under construction at Y-12). Any changes to CERCLA actions required as a result of the moratorium would be addressed in accordance with DOE's 1994 Secretarial Policy on NEPA. |
| 2* | General | The dominant source of radiological risk is the dose to truck crew members. Considering this, the EA's failure to indicate the assumed dose rate to truck crew members is a significant omission. The assumption should be stated. | DOT limits exposure rates in a truck cab carrying radioactive waste to less than 2mrem/hr (49 CFR 173.441). The statement, "This rate was used as a default exposure rate for transportation crew members" has been added to Sect. 4.3, Potential Exposure of Workers (page 4-6). The resulting assumed dose was based on 52 shipments/yr for the maximum mileage route. It is unlikely that exposure rates would be that high for most of the shipments and is thus quite |

Comment No.	Page/Reference	Comment	Response
3*	General	The individual dose to the maximally exposed truck crew member is stated to be 600 mrem/yr (page 4-28, para 1), which exceeds the 100 mrem-rem dose limit for members of the general public. If truck crew workers have the potential to receive this dose, then regulations and DOE's best interest both dictate that the truck crews be trained and monitored as radiation workers, which are allowed 5,000 mrem/yr. It appears, however, that DOE intends for the waste shipments to be done by commercial contract truckers (see page 4-30, last sentence of para 4), which might complicate the training and monitoring of truck crew members. The EA needs to discuss how this situation would be handled. (A similar concern applies to the maximally exposed rail crew member, although rail crew doses would be lower.)	conservative. DOT governs commercial shippers and the shipment of all types of materials, including radioactive materials. Drivers of all hazardous materials, including LLW, must be trained in the regulations and protocols of the DOT. They must be trained in the emergency response actions appropriate to the hazardous materials that they are transporting. Most radioactive waste shipments also require specific driver instruction on routing and emergency response. Just as DOE defines whether a material is radioactive, and if so, the type of radioactive material (e.g., low-level, transuranic, high level), DOT has developed its own categories to identify and manage materials that are shipped. Materials with radioactivity less than 70 Beq (0.002 nCi/g) need not be designated as radioactive material and are transported as miscellaneous hazardous waste under DOT regulations. Some LLW addressed in this EA would not be considered radioactive material by DOT due to very low levels of radioactivity and would be shipped as miscellaneous hazardous waste.
3* (continued)			If the radioactivity levels are low enough for LLW to be shipped as miscellaneous hazardous materials, the potential for crew (and public) exposures would be correspondingly lower and not approach the upper bounds modeled in the EA. It is the responsibility of the shipping company to comply with all applicable regulations for worker protection.
4*	General	The contrast between the quantitative analysis of the proposed action and the qualitative discussion of the no-action alternative (Section 4.5, beginning on page 4-34) gives the impression that the environmental consequences of waste transportation are far more serious than the consequences of continuing to store waste in Oak Ridge. To avoid this false impression, the discussion of the no-action alternative needs to be rewritten as an analytical discussion of impacts, instead of a dismissal of concerns. Specifically, Section 4.5.1 should provide estimates of	Waste storage does indeed carry potential exposure to radiation and the intent is not to dismiss this concern. Text has been added to Sect 4.5.1 discussing that while the exposure levels of individual workers is unlikely to increase because of worker H&S standards, the number of workers exposed to low levels of radiation would be more likely to increase. This was previously referred to as an increase in risk on a cumulative population basis. The following sentence has been added to para 1 of Section 4.5.1: "The likelihood of an accidental release occurring

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		annual worker exposure from performing the tasks included in managing waste on the ORR, in order to compare this continuing exposure with the one-time exposures associated with shipping. Section 4.5.2 should note that the potential for waste storage accidents would increase over time with the prolongation of storage.	would increase with the need to handle the waste, for example, to repackage it during prolonged storage." Text has also been added to the end of sentence 4 in Sect 4.5.3, "...required for the no action alternative." The following sentence has been added to Sect. 4.5.8, "Construction of new storage facilities would also represent a commitment of land for this purpose." Annual worker exposure to radiation is indeed monitored and maintained at ALARA levels on the ORR. However, workers do not typically work with only one waste stream; a worker may be inspecting a LLW storage area one day and handling other radiological materials the next. How much exposure occurs due to management activities for LLW only, and no other radiological waste streams, would be difficult to quantify. Since worker exposures to all radiological waste streams are within acceptable limits, it seems reasonable to use this exposure as an upper bound and state that exposures from LLW are a subset of these exposures and, therefore, within acceptable limits (see page 4-35).
4* (continued)		Commitment of ORR land for waste storage should be identified as a land use impact from the no-action alternative, and Section 4.5.6 should acknowledge that the construction of new waste storage facilities would mean loss of ecological habitat.	While the potential for construction of new storage facilities exists under the no action alternative, such an action is not being proposed in this EA. As noted on page 4-34, construction of storage facilities would be subject to NEPA review should it be proposed. Space is certainly present within developed and previously disturbed areas at the plants that could be used for such a purpose. Until potential sites for such an action were identified, it is not possible or appropriate to predict whether ecological habitat would be lost.
5	General	Please place the risks of transporting low-level waste (LLW) in perspective by comparing them to other types of hazardous waste and materials as ranked by U.S. DOT. Our understanding is that most of the LLW shipped from Oak Ridge falls into the category of lowest concern to DOT, miscellaneous hazardous.	A comparison has been added; see Sects. 4.4.4.2 and 4.4.5. Also see response to comment 3.

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		Specific comments	
1*	p 3-1, para 1	Says that the Reservation is outside of Oak Ridge. Should be revised to say that the ORR encompasses approximately 34,500 acres … "in and near" the city of Oak Ridge, Tennessee.	Agree.
2*	p 3-1, para 2	References to the 10-county region are perplexing. Presumably the ten counties include Roane, Anderson, Knox, Loudon, Blount, and Morgan, but the rest of the list is harder to guess. Other candidates include the downstream counties of Meigs, Rhea, and other East Tennessee counties where some ORR workers live, such as Campbell, Scott, Monroe, Cumberland, Sevier, and Union. This should be clarified.	Agree. Text on pg. 3-1 has been clarified.
3*	p 3-1, para 2	Delete the phrase that states that the city of Knoxville is the "major metropolitan area nearest Oak Ridge." This is misleading, since Oak Ridge is part (and the second center city) of the Knoxville metropolitan area.	Agree.
4*	p 3-1, last para	In addition to listing the distance from the southwestern ORR to I-40, it would be useful to give the distance from ETTP to I-40.	This will be done for informational purposes. As noted in response to comment 6, for risk modeling purposes, the ORR was considered one site.
5	Table 3.2	Add a footnote outlining what distances from the highways the populations were counted.	The footnote has been expanded to read, "…along the highway links for persons within 0.5 mi on each side of the route." This information is also presented in Sect. 4.3 (page 4-7).
6	Table 3.5	There is no map for the Kingston, Tennessee option; rather, the routes are described in Table 3.5. Provide a map of the route (of appropriate scale) that shows the three ORR sites. Additionally, give the highway distance from the three ORR sites, weighted by the waste distribution, used for the Kingston option in the analyses.	A figure was not provided because Kingston is a treatment destination, but waste would then continue on to a disposal destination. Text has been added to Sect. 3.2.1 to clarify this. Waste is routinely moved within the ORR, i.e., among the three sites. It is not feasible to attempt to designate the waste as coming from individual plants because it may be transported from the plant of origin, or from a different site where it has been stored. The ORR will continue to be considered a single point of origin for this NEPA analysis, as is appropriate for the scale of the proposed action and potential impacts from it.

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7		What truck accident rates were used for the Kingston option? Justify the use of any rates not determined from data specifically for the route.	The standard accident rate for category 3 roads was used for this route segment. The accident rates used in the RADTRAN model are representative of the highways in this assessment. Since the modeling conducted for this assessment is based on an assumption that the total volume of waste travels to each destination, it would be unduly biased to use site-specific data for the Oak Ridge point of origin and not for all segments of all routes.
8	Figures 3.1–3.5	Infer that I-40 exit 364 (SR95) will be used regardless of the direction to be taken on I-40 (east or west) and regardless of the ORR site from which wastes originate. Exit 356 is closer to ETTP than exit 364. The shortest distance west on I-40 is via SR 58 and exit 356 for all ORR facilities. Will use of SR 58 to exit 356 be prohibited? If so, how will it be enforced?	Text has been added to page 3-4. Exit 364 was chosen as a representative route because it is closer to the center of ORR and does not minimize the estimated mileage. However, use of Exit 356 would not be prohibited as there could be times that this route would be better. Given the relatively low risk levels posed by shipping LLW in general, differences in mileage between these two routes would be negligible.
9	Tables A.1 and A.2	These tables give truck accident rates used for freeways and "all others." The table footnotes divide the highway types into (1) freeways, (2) non-freeways, and (3) all others. Clarify the highways in "all others", it would seem there is nothing left compared to (1) and (2).	"Nonfreeways" are U.S. highways. "All others" are state, local, and community highways. The footnote has been clarified.
10	Tables A.1 and A.2	The immediate source of truck accident rates in these tables appears to be the 1997 Waste Management Programmatic Environmental Impact Statement. The rates appear to be held constant for all routes. What is the source of these rates and how do they vary by route?	Accident rates are the same for Tables A.1 and A.2 because the likelihood of an accident is not influenced by the shipping contents, i.e., scrap metal or heterogeneous waste. The accident rates are default rates for the RADTRAN 4 computer program; they were also used for the 1997 WM-PEIS. Accident rates are influenced by both road type and population zone.
11		If the truck and/or train accident rates were held constant across all routes, how is this assumption justified given that specific routes, and associated mileage and population values, were determined for each option in this EA?	Rates are constant only within a road type and population zone combination. The total distances traveled over each combination route type do vary between the options.
12		Onsite truck transportation to rail loading areas at either Y-12 or ETTP appears to have been neglected. Is this correct?	Yes, that is correct. Transportation within and between the plants was not estimated for reasons stated in response to comment 6. Waste is routinely moved within the ORR, i.e., among the three sites. It is not feasible to attempt to designate the waste as coming from individual plants because

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			it may be transported from the plant of origin, or from a different site where it has been stored. The ORR will continue to be considered a single point of origin for this NEPA analysis, as is appropriate for the scale of the proposed action and potential impacts from it.
13	p 4-3, para 4	contains the statement that to assume shipment using a 55-gal drum is conservative because more waste can be shipped in a single shipment. This assumption is conservative for radiological analyses where the consequences are proportional to the amount involved. This assumption is not conservative, however, for non-accident analyses and for accident analyses not related to the shipment contents because for these cases the risk is proportional to the number of shipments. Non-accident risks are clearly dominant pursuant to Tables 4-4 through 4-13.	The statement has been corrected to read that "less" waste, "but with more container surface area," can be shipped per shipment. This is conservative because it does not minimize the number of shipments. Radiological analyses are also conservative because the larger number of containers (drums) have a greater collective surface area from which radioactivity can be emitted.
14	p 4-3, Sect 4.2.3	mentions both a baseline disposition case and an accelerated disposition case. Neither is described and it is not clear to which case Tables 4.2 and 4.3 apply.	The text in Sect. 4.2.3 has been clarified. An accelerated disposition scenario for legacy waste was used as the baseline to conservatively bound potential risk on an annual basis. The disposition schedule would not affect risks on a per shipment basis or 20-year life cycle basis, but only in evaluating risks on an annual basis.
15	Table 4.3	lists the rail shipments and the total adds up to the same volume as the truck shipments. Since Type B waste are to be shipped only by truck, the rail volume should add up to 182,160 m^3, not 184,000. It is conservative to use the higher value for rail shipments but not necessarily conservative to ignore the truck shipments of 1,840 m^3 of Type B wastes in the rail option. Justify the assumption.	Truck shipments of Type B wastes were not ignored. As stated in Sect. 2.1, "ORR LLW will generally be transported by truck, but may be transported by rail ... when advantageous." The potential impacts from using either of these transportation modes are being considered in comparison to the no action alternative and not as highway versus rail. As stated on p 4-19, "...life cycle estimates were calculated based on shipment of all LLW (except Type B LLW) to each given destination." Because Type B waste is less than 1% of the total waste, the volume disappears in the 99% that could be shipped by rail in rounding the numbers.
16	p 4-8	The statement that the Knoxville-Oak Ridge air pollutants don't exceed standards is incorrect, based on the new Clean Air regulations. The greater Knoxville metropolitan area is out of compliance with the new ozone standards.	The new 8-hr standard for ozone has been revoked by EPA pending resolution of a court case over it. EPA recently reinstated the previous 1-hr standard in order to have a standard in place. Text has been added clarifying this and

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Comment No.	Page/Reference	Comment	Response
			adding that the area would likely be designated a nonattainment area if the 8-hr standard is reinstated. It has also been noted that estimated emissions from all shipments are below thresholds requiring conformity analysis.
17		What is assumed to be the radiation level of the shipments on which the hazard levels have been computed? If it is the maximum (1 mrem/hr at one meter from most shipments), the conservatism would be well worth stressing, because the average will presumably be lower. However, in comparison to hazardous materials currently moving on the interstate, the increased risk to the public from these shipments is relatively insignificant.	Agree; the source term used was 1 mrem/hr (see Table 4.1). The point will be stressed.
18	Tables 4.4 through 4.13	should more clearly indicate that row 3 is the sum of rows 1 and 2; that row 5 is the sum of rows 3 and 4; and that row 6 are independent values.	Agree. A footnote for row 3 has been added and the footnote for row 5 has been expanded.
19	Sect 4.4.4.1	Consider deleting this section. Results are given from other studies but are not well correlated to the present study. The fact that the other studies have concluded LLW transportation risk is negligible is of no value. The doses presented in this EA should be defended as negligible on their own merits.	Results from other studies were presented for two reasons. The first reason is to provide a relative context for estimated ORR risks when compared to other shipments, such as all shipments nationwide or all shipments within the DOE complex. The second reason is to present estimated ORR risks within the context of the studies this EA is tiered under.
20*	p 4-17, para 3	Here and elsewhere, the calculated risk estimates to truck crews are stated to be risks to two workers, if those same two crew members drive all shipments over twenty years. This statement is not accurate. The calculated values are not risks to individuals, but collective risks to the entire population of truck crew members over the twenty-year period. This error in explaining the meaning of the results should be corrected throughout.	Although it is not likely, or possible, that the same two truck crew members would be on all shipments, it is conservative to present the risk estimates in this manner. The maximum risk to a truck crew member is for a single, hypothetical crew member engaged in all shipments. The total risks to all individuals would be multiplied by the number of truck crew members (usually two).

*The nine comments submitted by the City of Oak Ridge Environmental Quality Advisory Board mirrored some of the comments submitted by the Local Oversight Committee (general comments 1, 2, 3, and 4 and specific comments 1, 2, 3, 4, and 20).

LLW Environmental Assessment Comment Record

Title of Document: *Environmental Assessment for the Transportation of Low-Level Radioactive Waste from the Oak Ridge Reservation to Off-Site Treatment or Disposal Facilities*

Document number or other identifier: DOE/EA-1315

Name of Commentor:	**Sharon G. Morris**
Organization of Commentor:	**ARK-TEX Council of Governments**

Comment No.	Page/ Reference	Comment	Responses
		Comments from the ARK-TEX Council of Governments	
1	General	The above-referenced project will be presented to the ARK-TEX Council of Governments Board of Directors for review on Thursday, June 29, 2000. You are invited to attend the meeting.	Thank you. No other correspondence was received from this organization.

LLW Environmental Assessment Comment Record

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Name of Commentor: Terry Roberts

Organization of Commentor: State of California, Governor's Office of Planning and Research, State Clearinghouse

Comment No.	Page/Reference	Comment	Responses
		General comments	
1	General	No state agencies submitted comments. This letter acknowledges that you have complied with the State Clearinghouse review requirements for draft environmental documents, pursuant to the California Environmental Quality Act.	Thank you.

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LLW Environmental Assessment Comment Record

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Name of Commentor:	Heather K. Elliott
Organization of Commentor:	State of Nevada, Department of Administration, State Clearinghouse

Comments from the Nevada Division of Emergency Management

Comment No.	Page/ Reference	Comment	Responses
1	General	As there is currently a program that is active under this division for issues relating to the transportation of low-level waste in Nevada, it is my preference that any other programs addressing this issue would be coordinated with the planning efforts already in progress. Presently, this program is providing assistance to Clark, Elko, Esmeralda, Lincoln, Nye, and White Pine counties in the areas of emergency planning, training, and exercise.	Agree.
2	General	I believe that coordination of existing programs and any additional programs that may be received by this state would assist in providing a comprehensive approach to this issue and avoid possible duplication of efforts and unnecessary costs.	Agree.
3	General	As many of our local jurisdictions are small and unable to afford an independent program in support of issues of this nature, our division seeks to maximize their gain in preparing for all potential emergencies/disasters.	Agree.

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Document number or other identifier: DOE/EA-1315

Name of Commentor: Angela F. Stoner

Organization of Commentor: State of South Carolina, State Budget and Control Board

Comment No.	Page/ Reference	Comment	Responses
		Comments from the South Carolina Department of Agriculture, Larry Boyleston	
1	General	Project is consistent with our goals and objectives.	Thank you.
		Comments from the South Carolina Department of Commerce, George Bistany	
2	General	No comment.	Thank you.
		Comments from the South Carolina Department of Labor, Barbara Derrick	
3	General	Project is consistent with our goals and objectives.	Thank you.

LLW Environmental Assessment Comment Record

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Document number or other identifier: DOE/EA-1315

Name of Commentor: Earl C. Leming

Organization of Commentor: State of Tennessee, Department of Environment and Conservation, DOE Oversight Division

Comment No.	Page/ Reference	Comment	Responses
		General comments	
1	General	The DOE Oversight Division is encouraged by DOE's efforts to remove waste that pose potential and substantial risk to human and the environment. The Division expects DOE to increase initiates in this positive direction of waste management on the ORR.	Thank you.
		Specific comments	
2		DOE is in the process of completing a lease agreement with a "private" organization for the use of the rail system at ETTP. Large volumes of waste and other materials will be transported off-site via road and rail over the next several years to achieve an end state of commercial/industrial land usage for the entire ETTP. What mechanisms or controls does DOE have in place that will ensure that leasing the rail lines will not adversely influence CERCLA and Waste Management responsibilities to manage waste on the site?	Transportation of LLW may be by either highway or rail. Thus, rail is not the only transportation option. DOE is not anticipating that constraints in rail transport would occur or pose a roadblock to shipping LLW. As stated in Sect. 2.1, "ORR LLW will generally be transported by truck, but may also be transported by rail or intermodal carrier (i.e., truck and rail combination) when advantageous."
3		The risk of an accidental release during loading and off-loading of the low-level waste should be calculated and reported as an integral part of the document.	The potential risk that could result from an accidental release during loading or unloading is conservatively bounded within the transportation accident scenario analyses. Loading and unloading occur on an ongoing basis as part of routine operations for waste management activities.

LLW Environmental Assessment Comment Record

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Name of Commentor: Denise S. Francis
Organization of Commentor: State of Texas, Office of the Governor

Comment No.	Page/ Reference	Comment	Responses
		Comments from Strategic Assessment Division of TNRCC on air quality	
		Comments from the Texas State Implementation Plan Development Section, Ken Gathright:	
1	General	Dallas and Tarrant counties are nonattainment counties for ozone, and general conformity rules apply for these counties. An increase of 50 tons per year for VOCs or NOx could trigger conformity requirements. However, emissions from the proposed project are expected to be well below these levels. Therefore, a general conformity analysis will not be required.	Agree.
		Comments from the Texas State Policy and Regulation Section, Clyde Bohmfalk:	
2	General	No comments.	Thank you.
		Comments from the Texas State Remediation Division, Randy Arnett:	
3	General	No comments.	Thank you.

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